Exceptional service in the national interest

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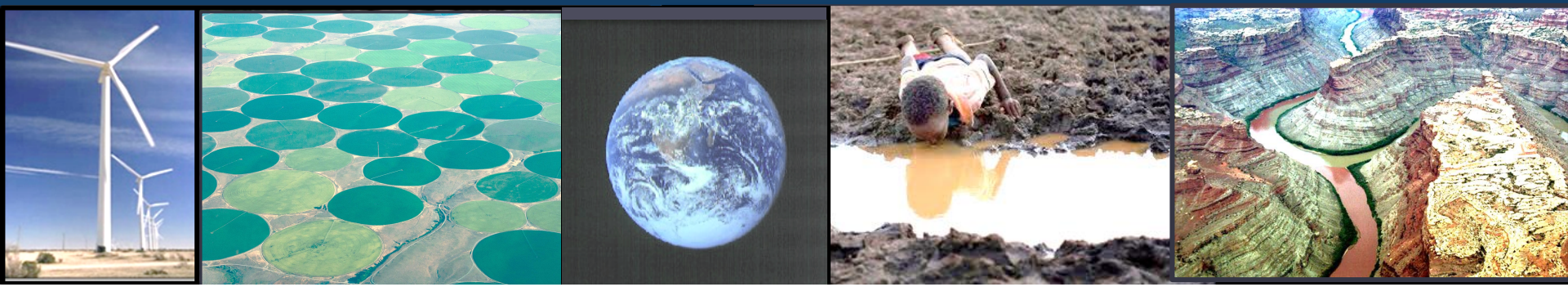

Energy-Water-Food-Ecosystems

Global Interdependencies and Trends

Howard Passell, Sandia National Labs
hdpasse@sandia.gov

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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Two main messages

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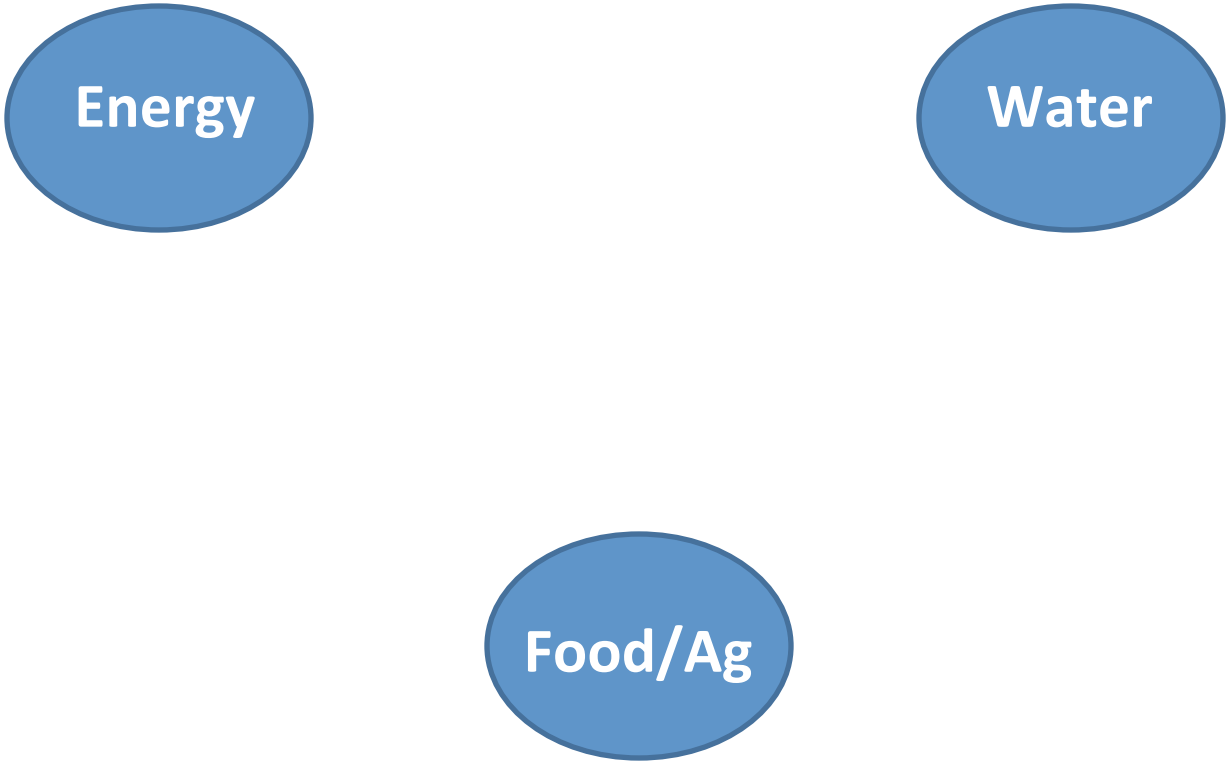
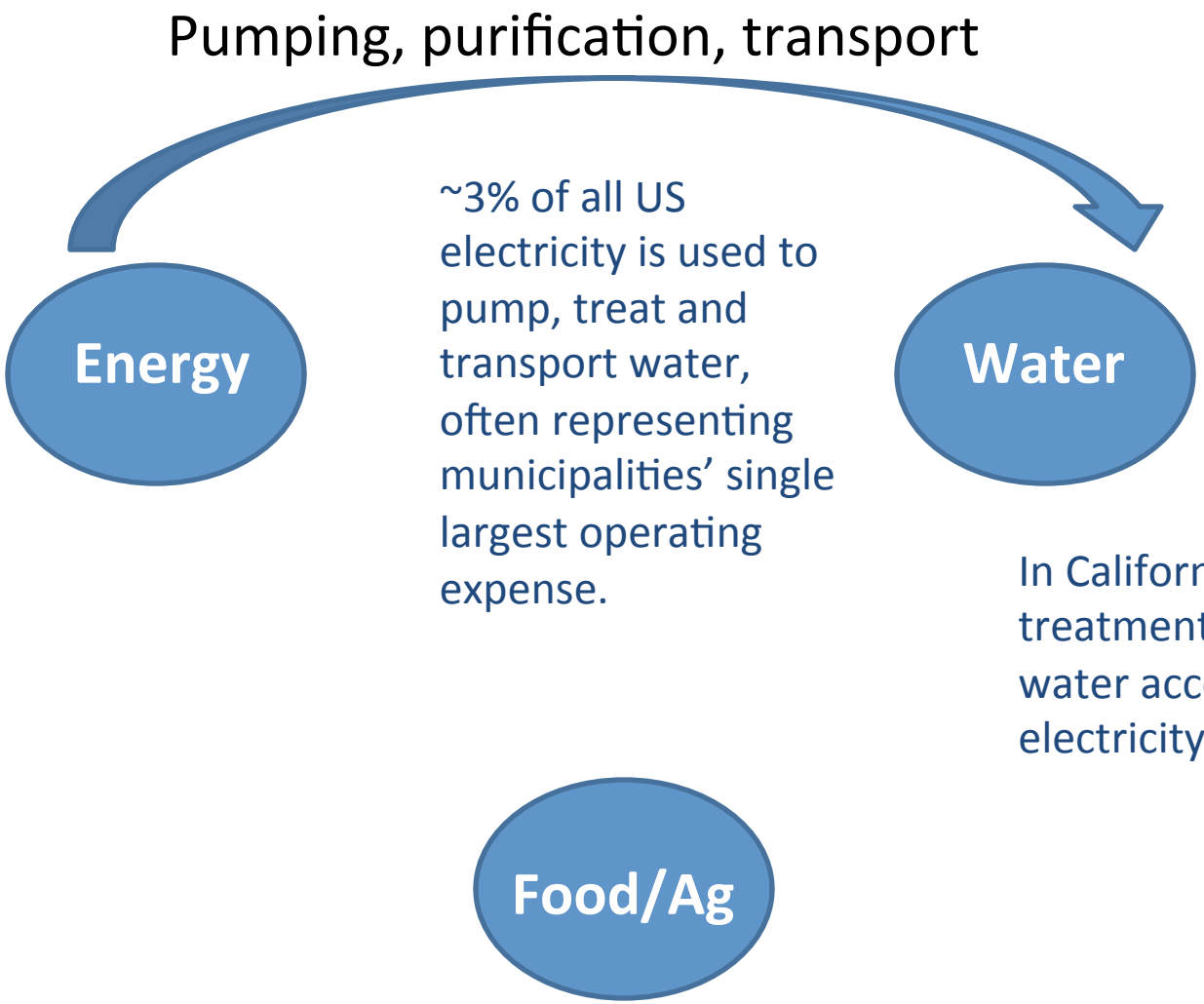
1. Energy, water, agriculture/food, and ecosystem services are all connected.
   - This is a no brainer—one Earth, one atmosphere, one biosphere, etc.
   - *How* are they connected? That's the question . . .
2. Three robust, long-term, slow-to-change global trends are critical.
   - Population is increasing.
   - Consumption of all resources (water-energy-food, ecosystems services) is increasing.
   - Resource availability is decreasing.

No Gloom and Doom!

Energy-water-agriculture: All interdependent & set within ecosystems



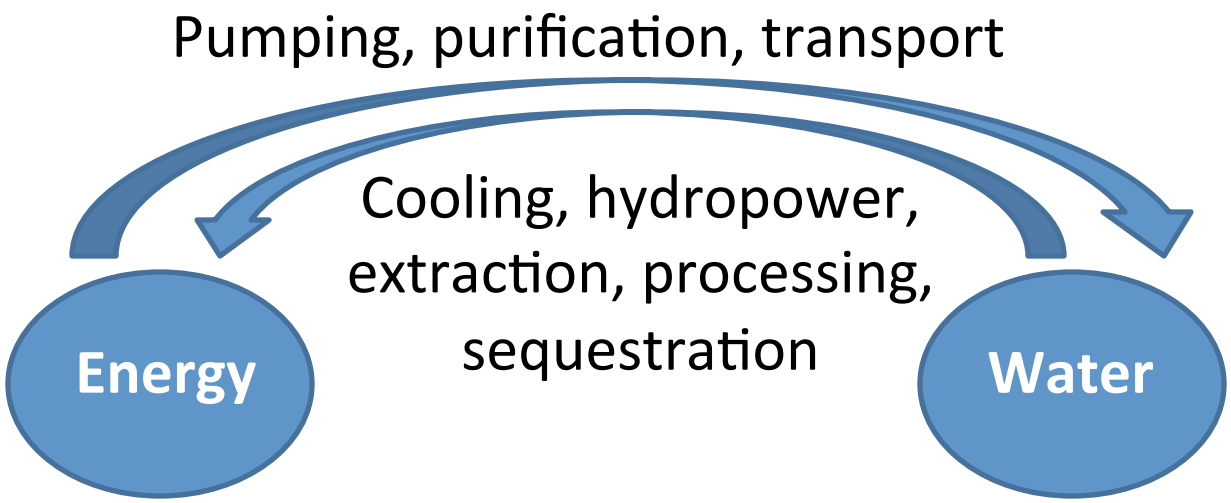
Energy-water-agriculture: All interdependent & set within ecosystems



~3% of all US electricity is used to pump, treat and transport water, often representing municipalities' single largest operating expense.

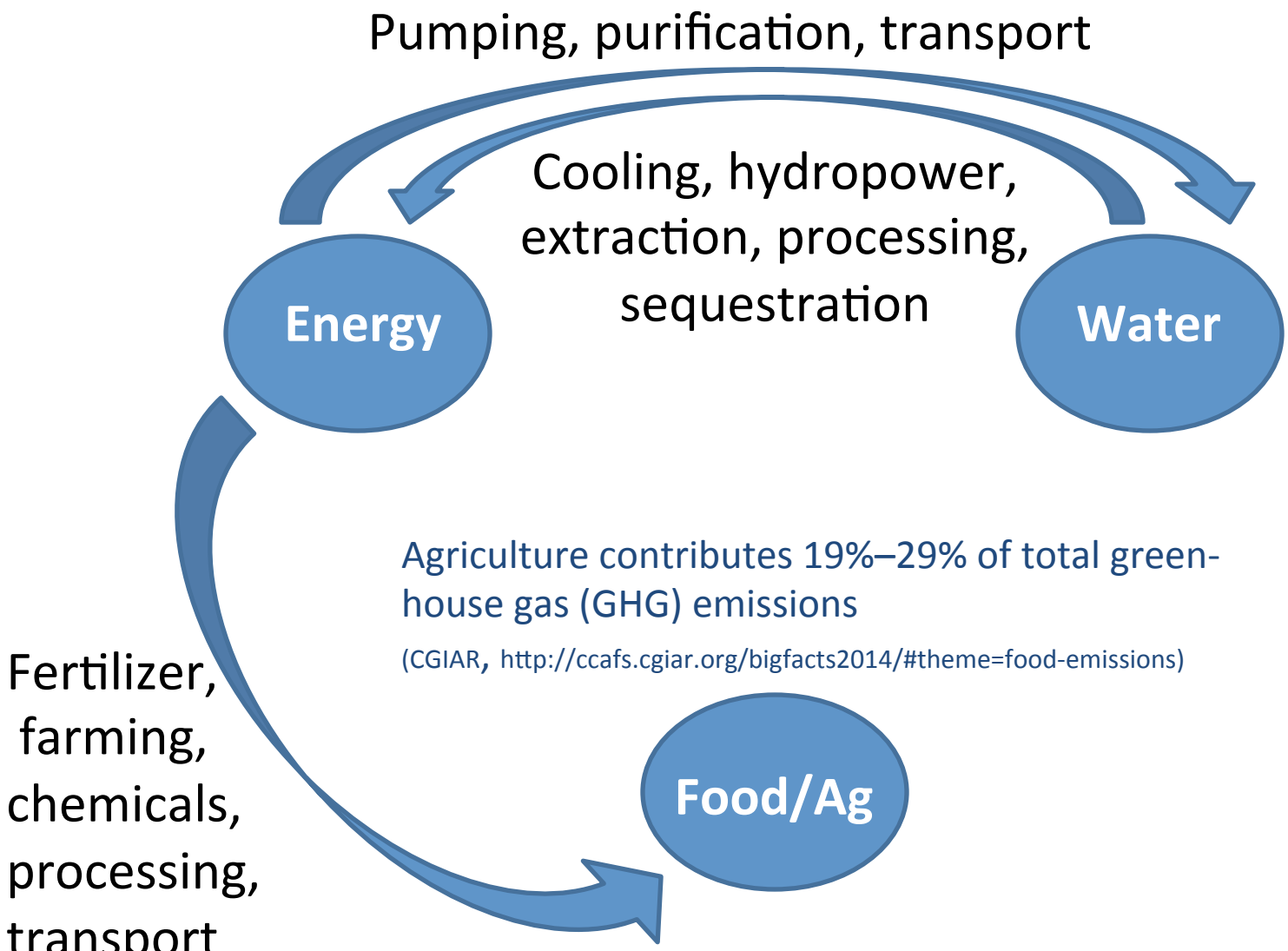
In California, transport, treatment, and heating of water accounts for 20% of electricity consumption.

Energy-water-agriculture: All interdependent & set within ecosystems

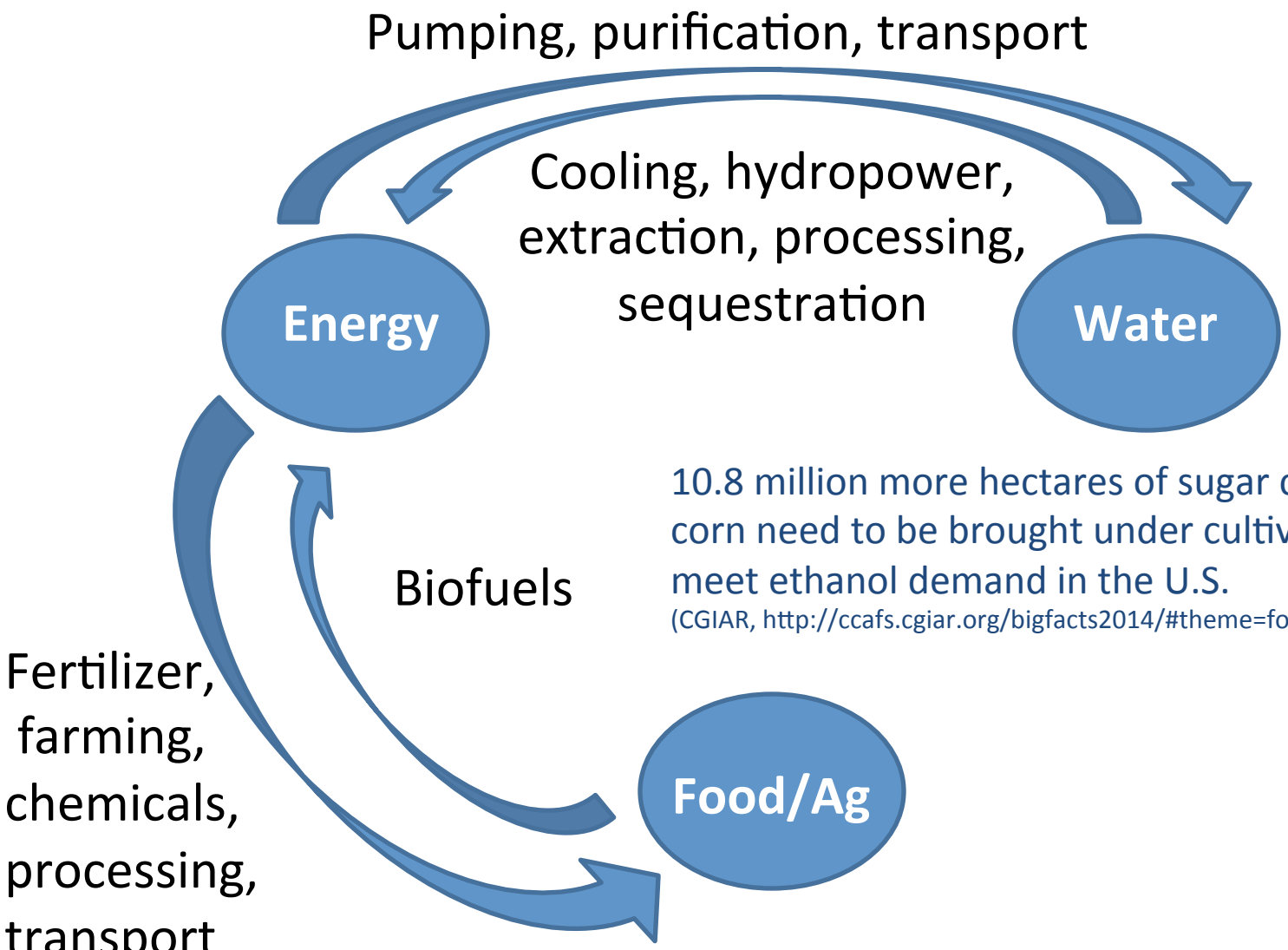


About 40% of U.S. water withdrawals are to cool thermoelectric power plants. This amount is roughly equal to the withdrawals for agriculture. Only about 3% is consumed.

Energy-water-agriculture: All interdependent & set within ecosystems

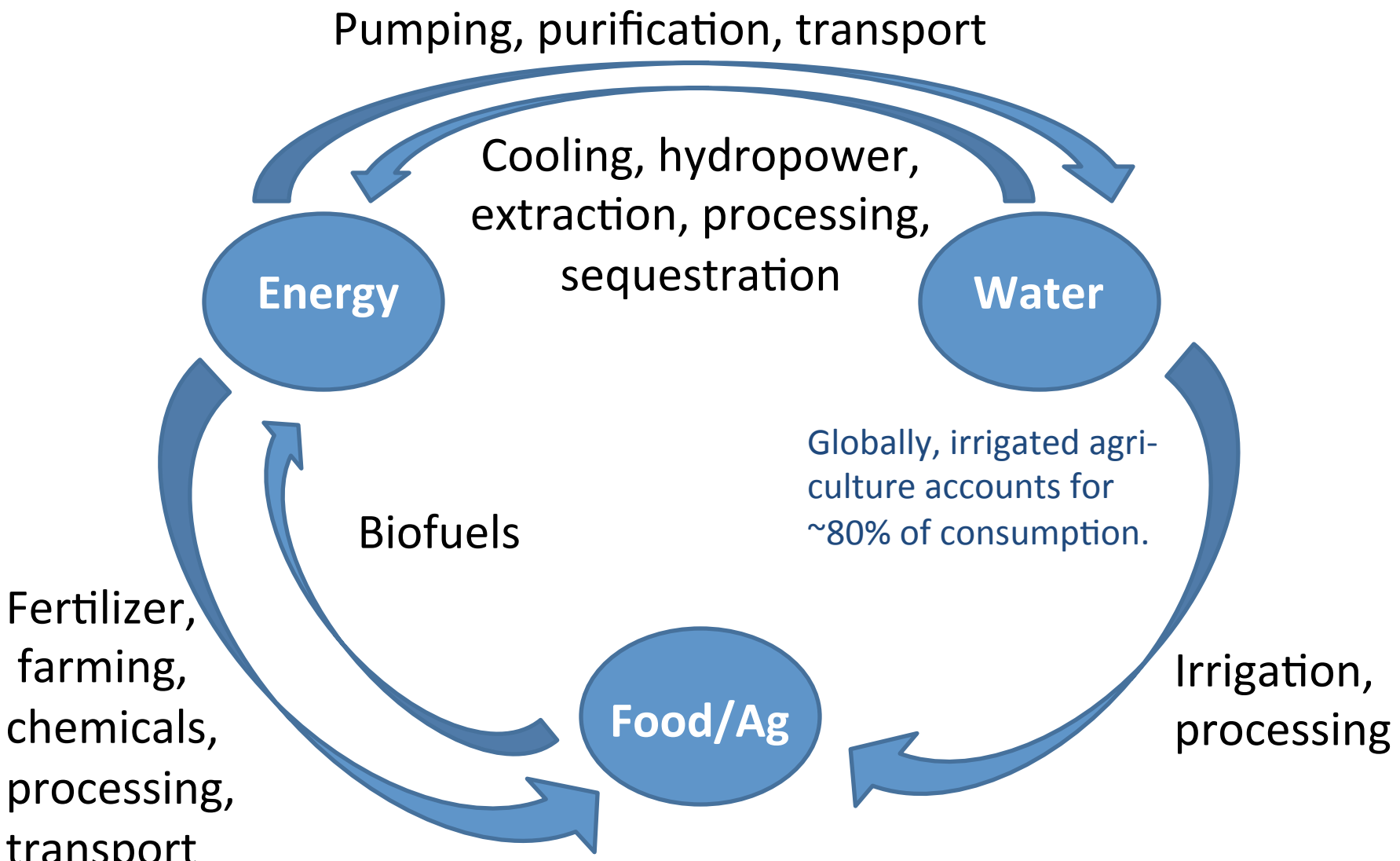


Energy-water-agriculture: All interdependent & set within ecosystems

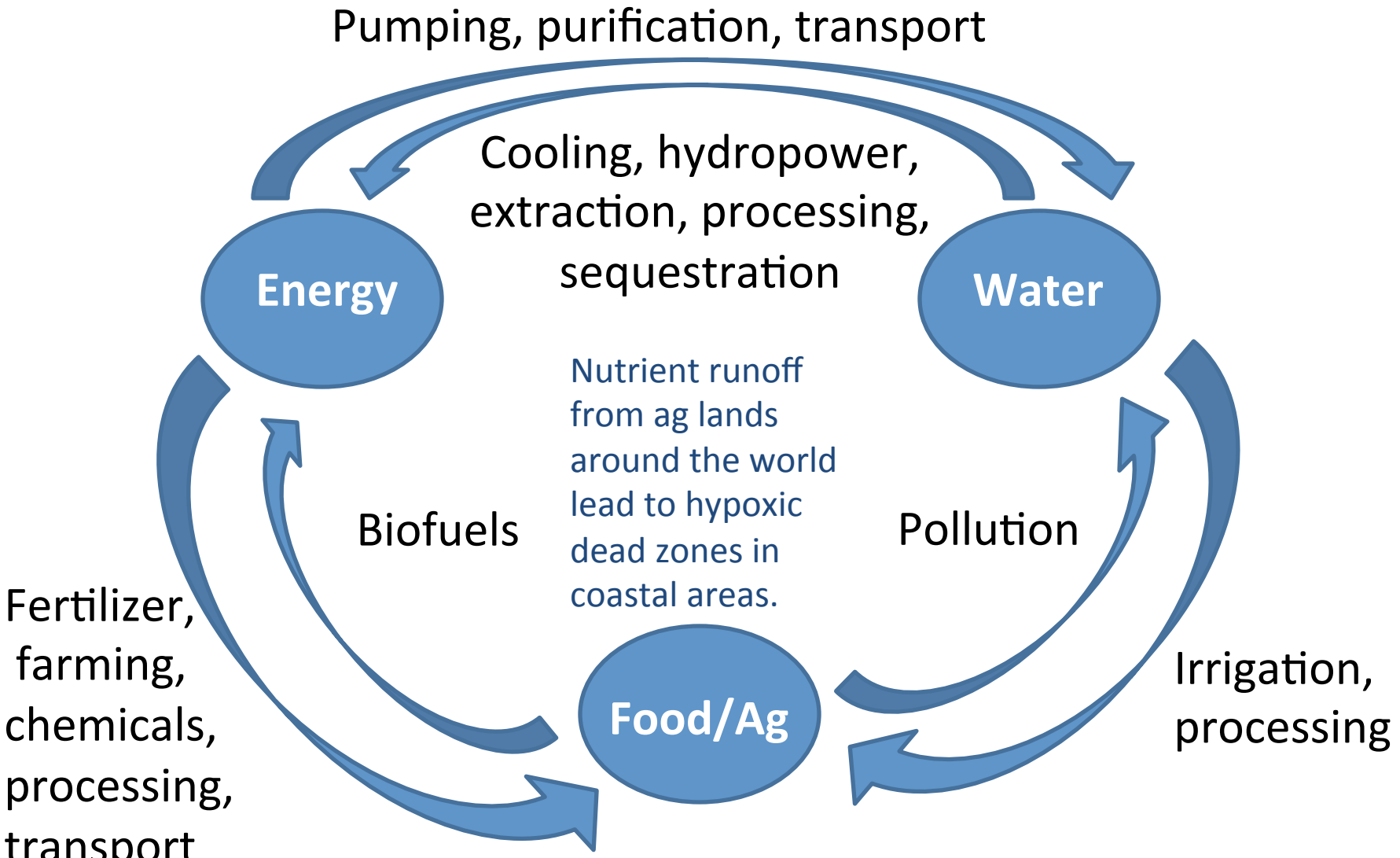


10.8 million more hectares of sugar cane and corn need to be brought under cultivation to meet ethanol demand in the U.S.
(CGIAR, http://ccafs.cgiar.org/bigfacts2014/#theme=food-emissions)

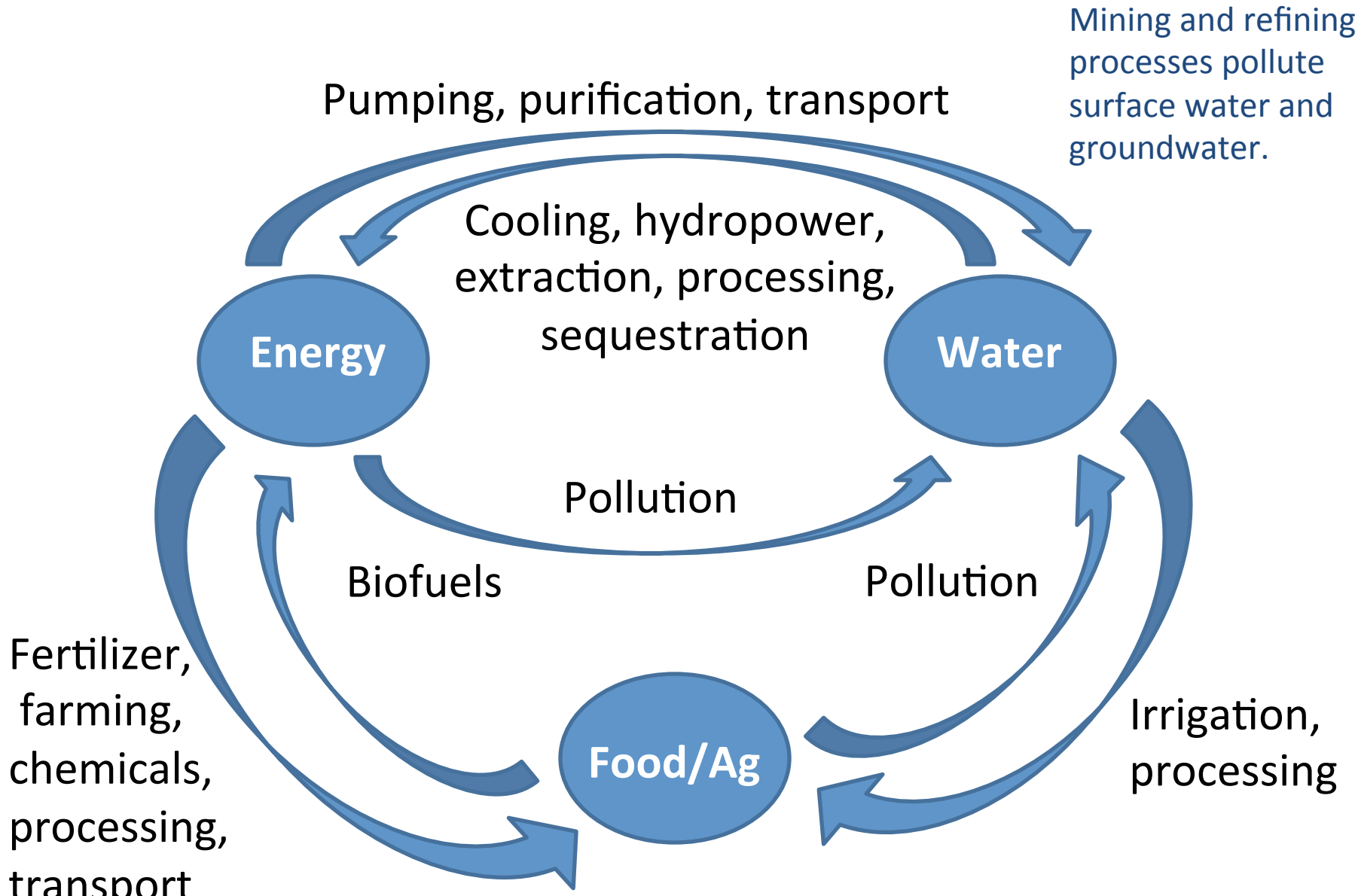
Energy-water-agriculture: All interdependent & set within ecosystems



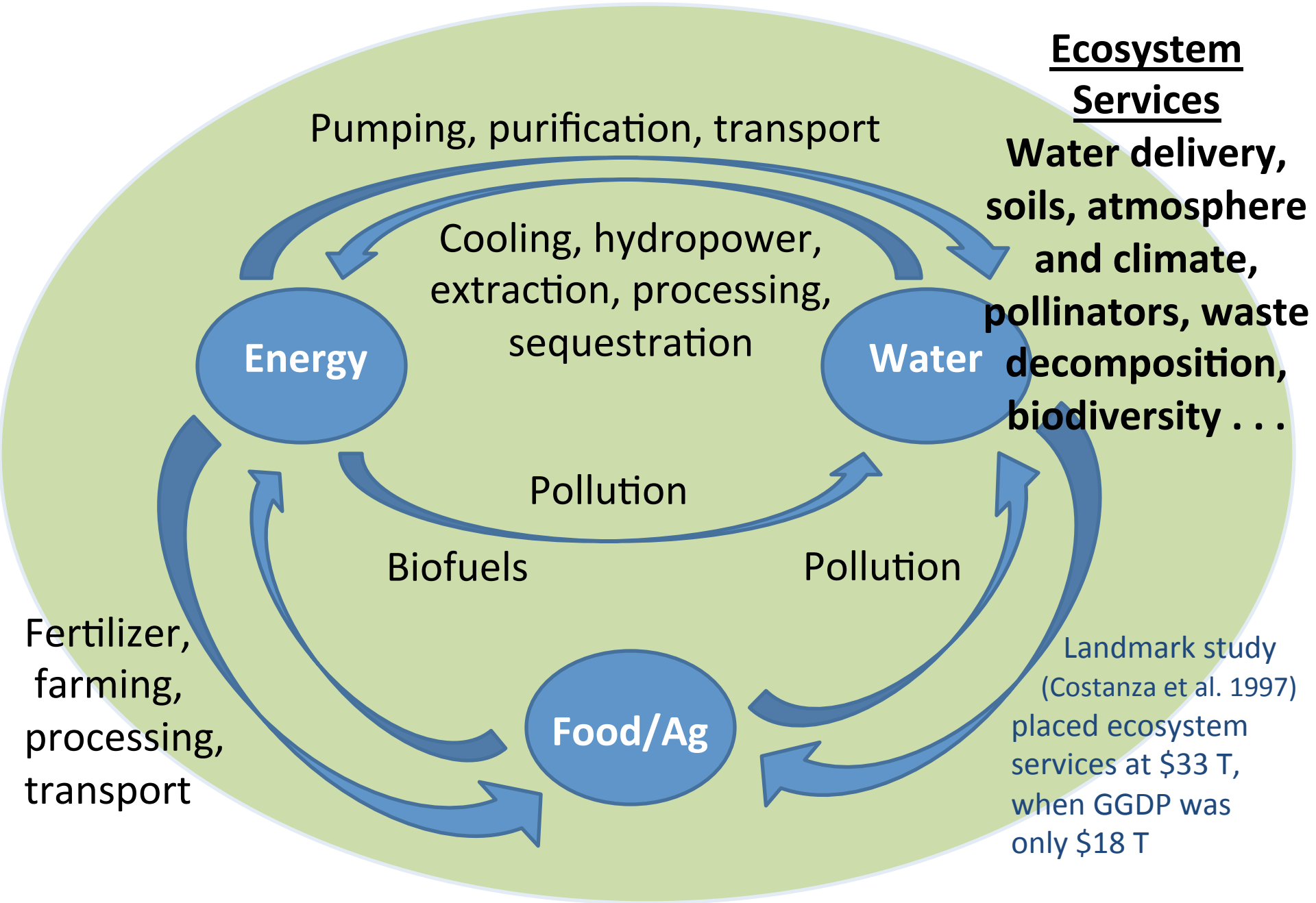
Energy-water-agriculture: All interdependent & set within ecosystems



Energy-water-agriculture: All interdependent & set within ecosystems



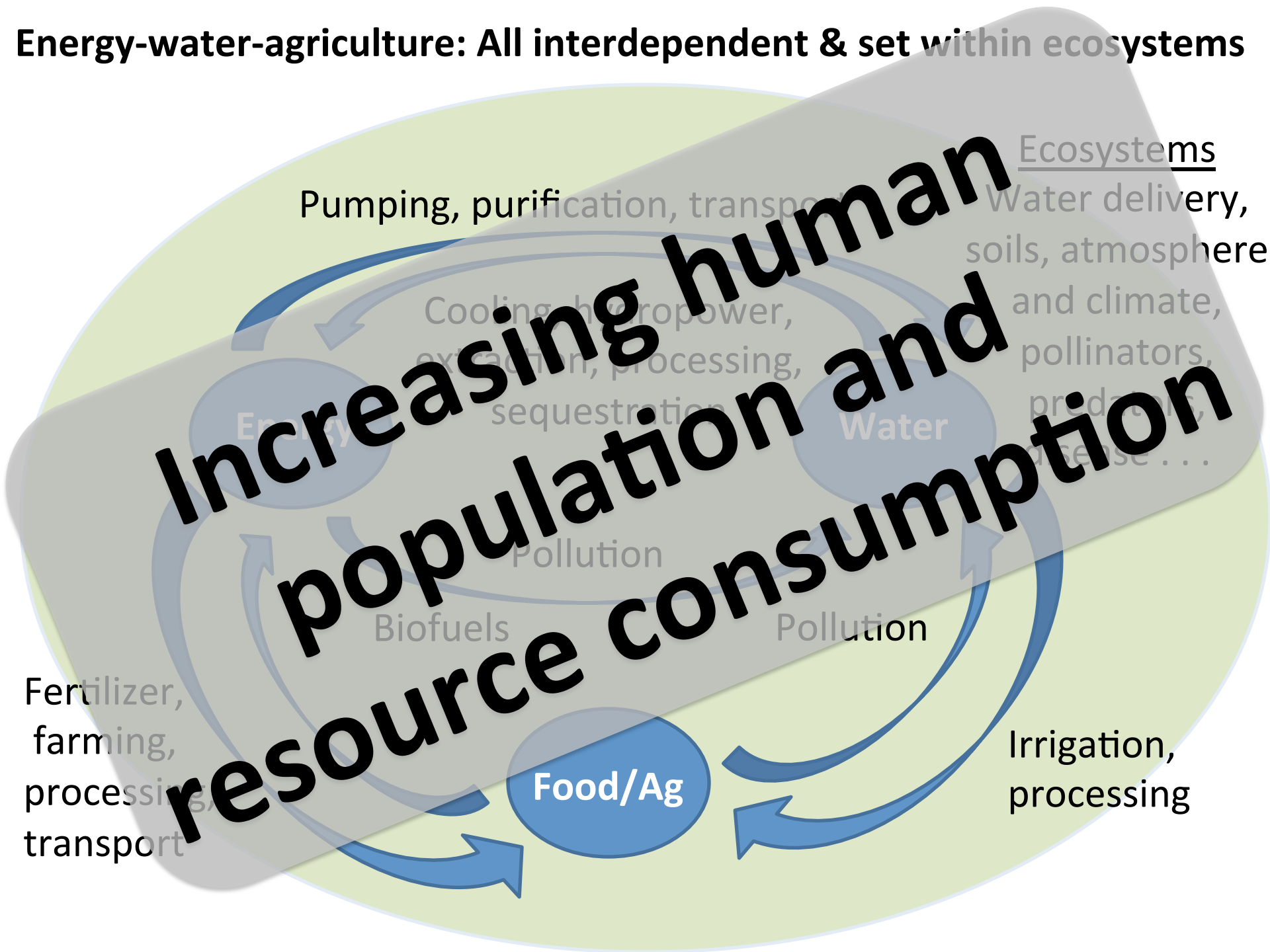
Energy-water-agriculture: All interdependent & set within ecosystems



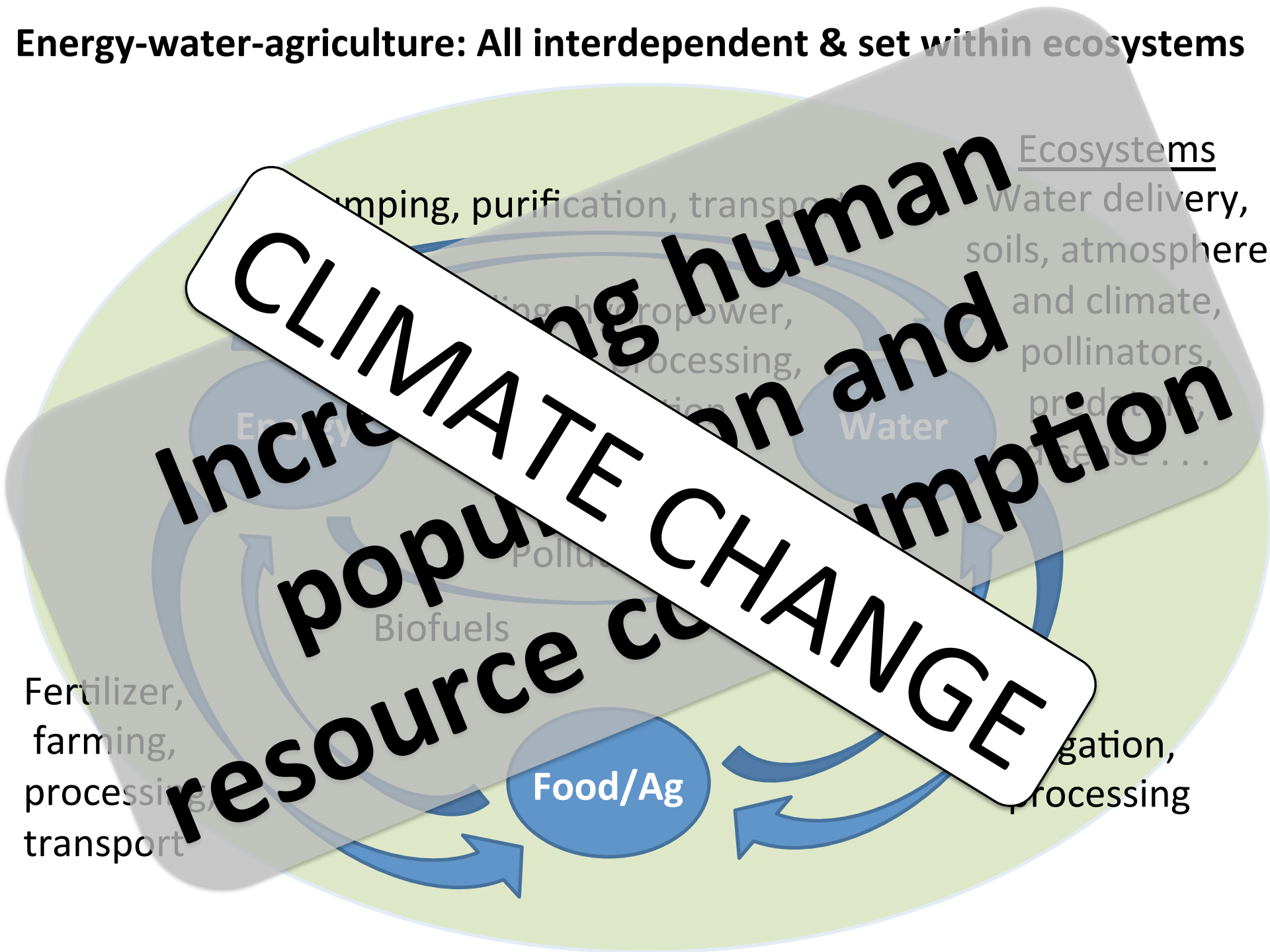
Ecosystem Services

Water delivery, soils, atmosphere and climate, pollinators, waste decomposition, biodiversity . . .

Landmark study (Costanza et al. 1997) placed ecosystem services at $33 T, when GGDP was only $18 T


Energy-water-agriculture: All interdependent & set within ecosystems
Increasing human population and resource consumption
Pumping, purification, transport
Ecosystems
Water delivery, soils, atmosphere and climate, pollinators, predation, disease . . .
Cooling, hydropower, extraction, processing, sequestration
Energy
Water
Pollution
Biofuels
Pollution
Fertilizer, farming, processing, transport
Food/Ag
Irrigation, processing

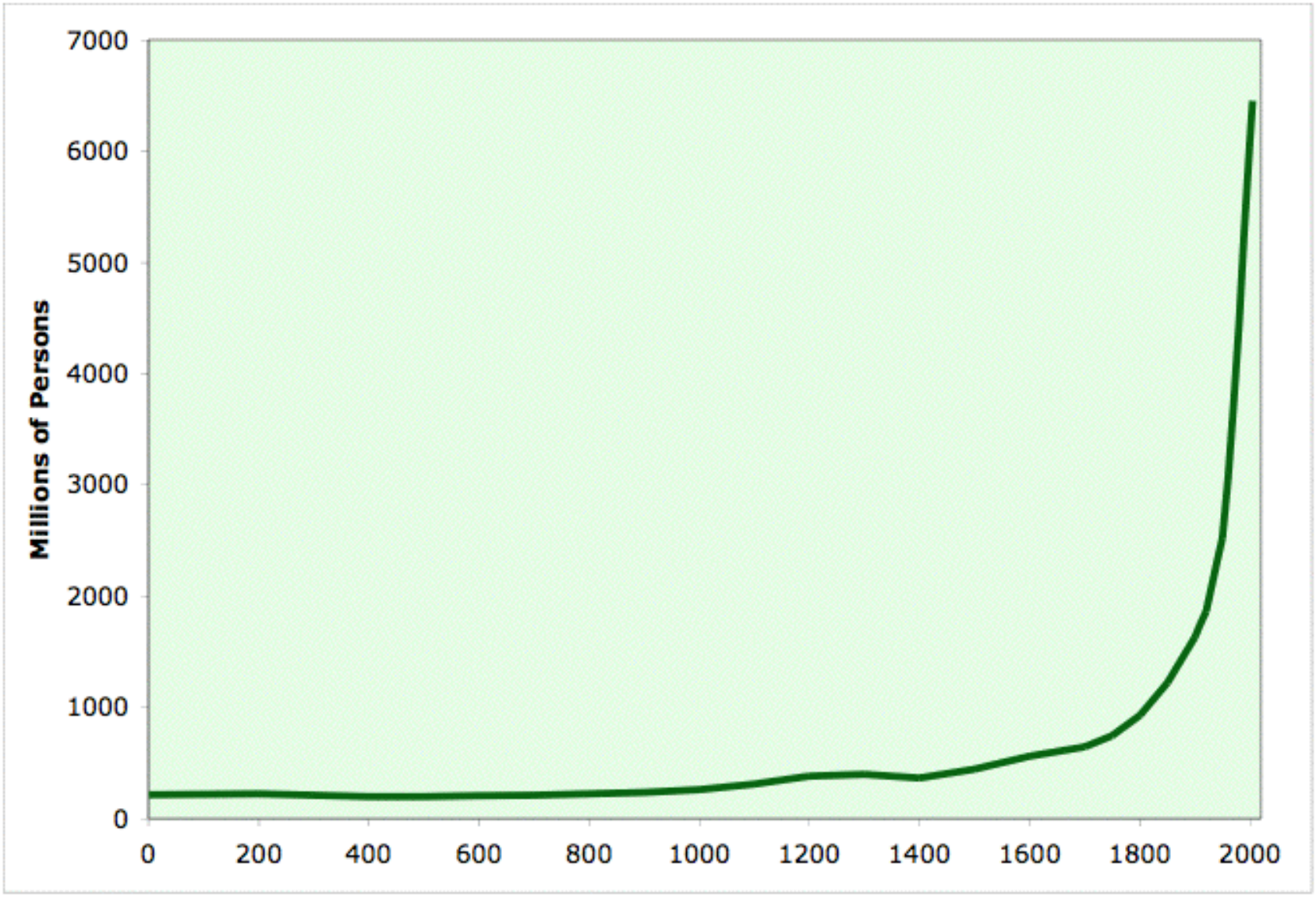
Energy-water-agriculture: All interdependent & set within ecosystems



Increasing human population and resource consumption

CLIMATE CHANGE

Population growth, long-term and global

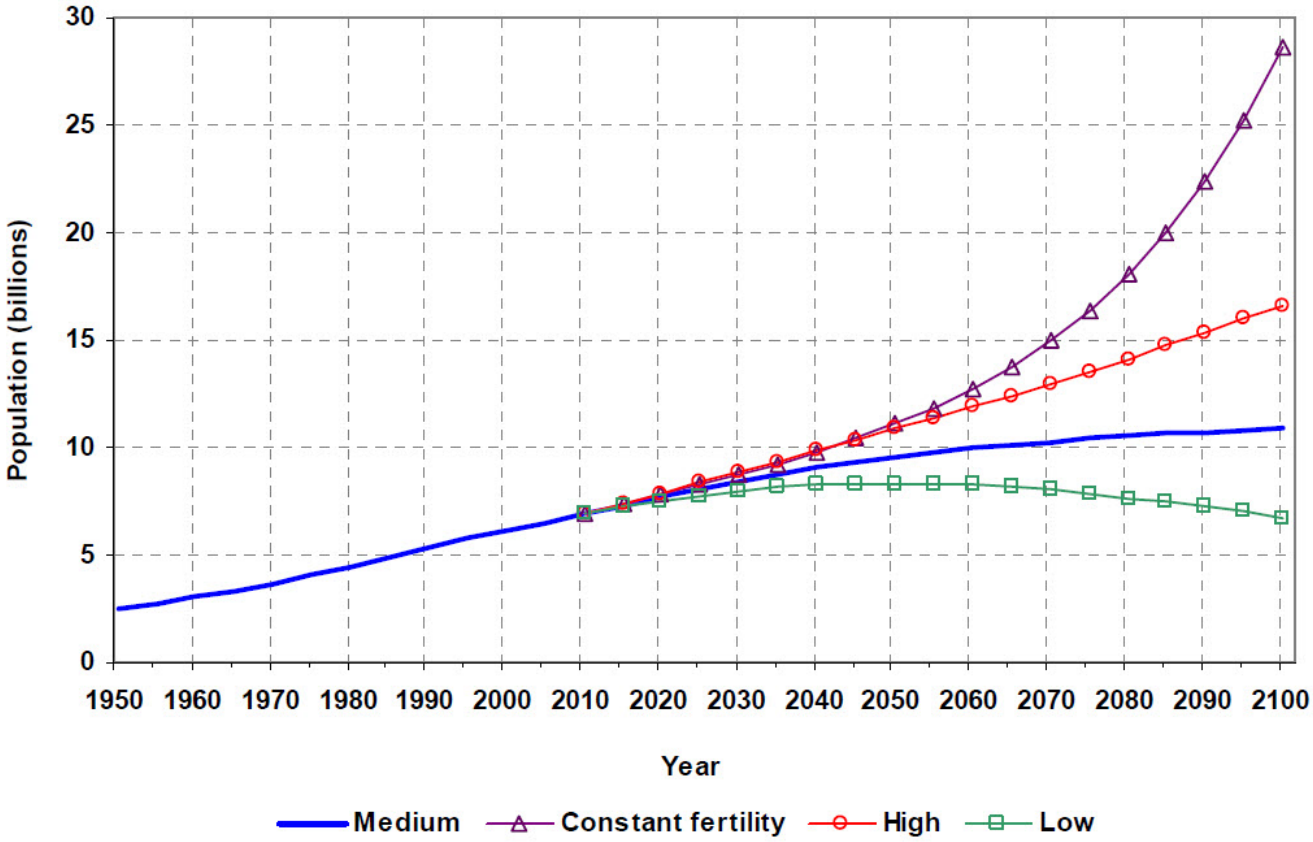


Population growth, UN Projections to 2100

. . . the world population of 7.2 billion in mid-2013 is projected to increase by almost 1 billion people within the next 12 years, reaching 8.1 billion in 2025, and to further increase to 9.6 billion in 2050 and 10.9 billion by 2100.

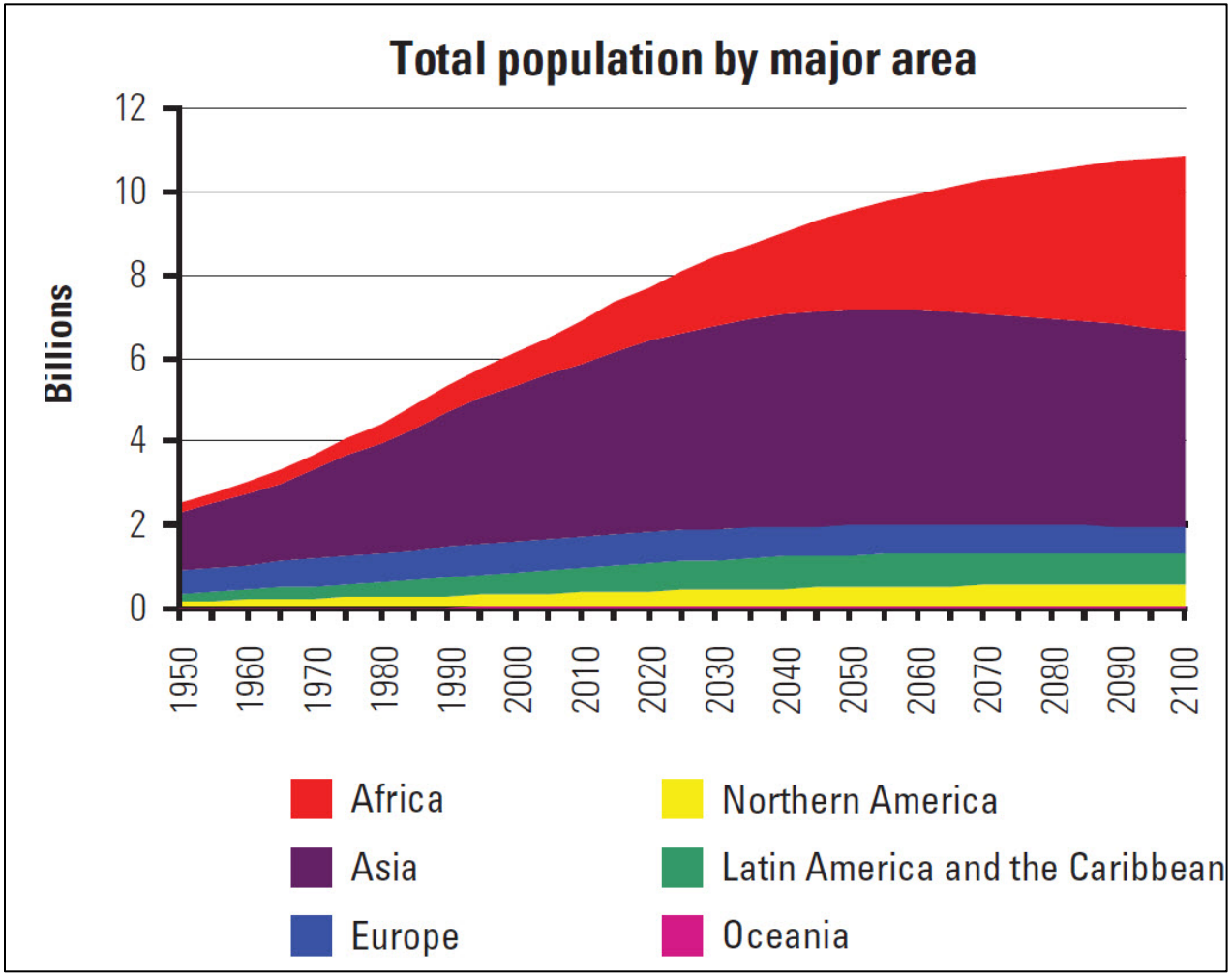
UN World Population Prospects, the 2012 Revision.

Figure 1. Population of the world, 1950-2100, according to different projections and variants



Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2013). *World Population Prospects: The 2012 Revision.* New York: United Nations.

Population growth by region



Thirty five of the UN's 49 'least developed countries' (many in Africa) could see population increase by factor of 3.

Eight countries could see population increase by a factor of 5: Burundi, Malawi, Niger, Nigeria, Somalia, Uganda, Tanzania, Zambia

UN World Population Prospects, the 2012 Revision.

Big Facts on Climate Change, Agriculture, and Food Security, Consultative Group on International Agrictultural Research (CGIAR) http://ccafs.cgiar.org/bigfacts2014/#

Energy demand will increase by ~50%

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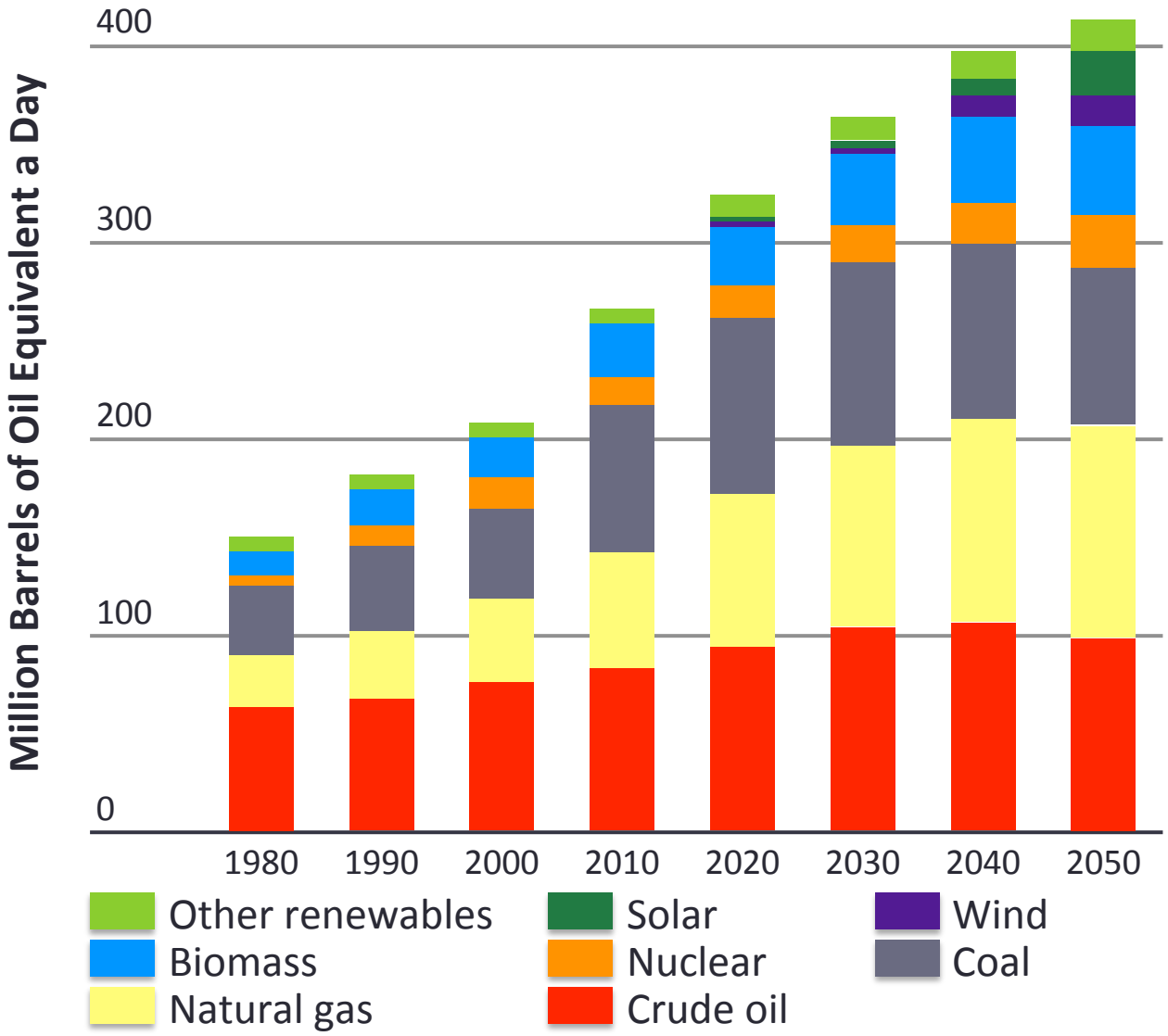

Projected Global Energy Demand to 2050

Shell Sustainability Report 2012
http://reports.shell.com/sustainability-report/2012/ourapproach/buildingasustainableenergyfuture.html

Declining energy availability??

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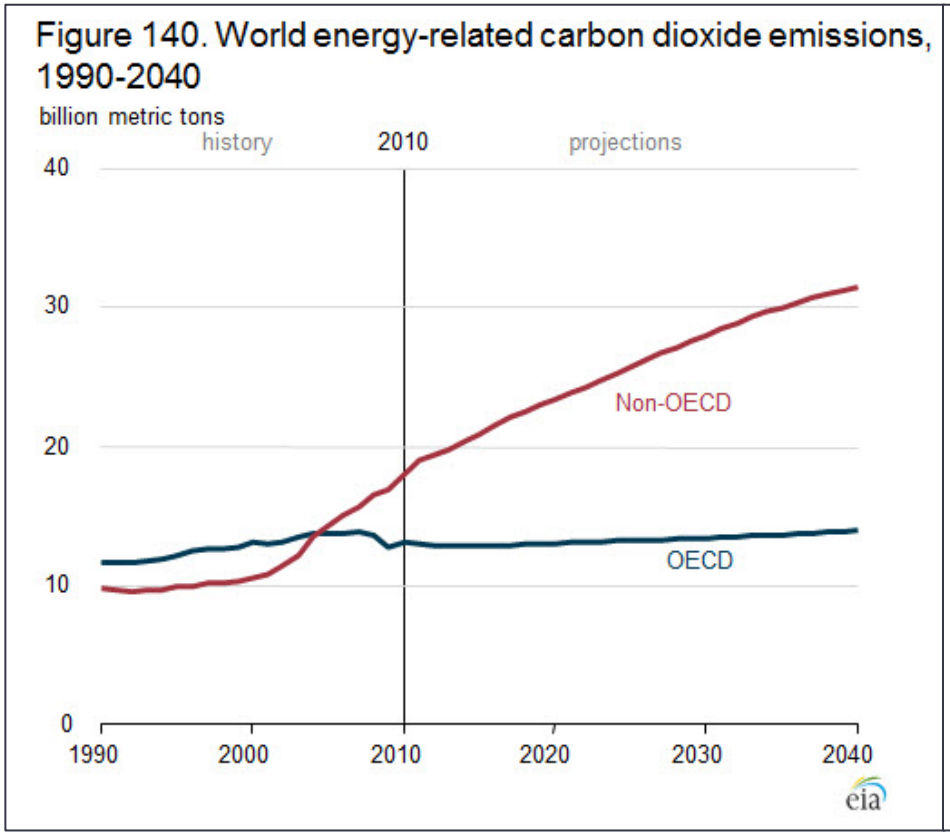
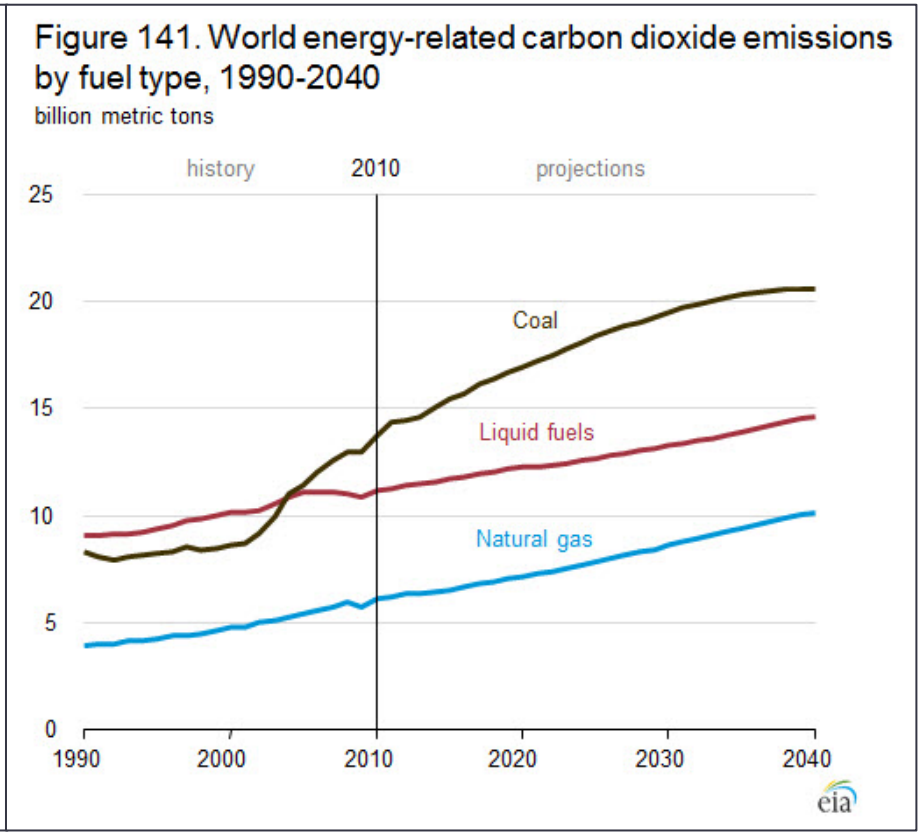
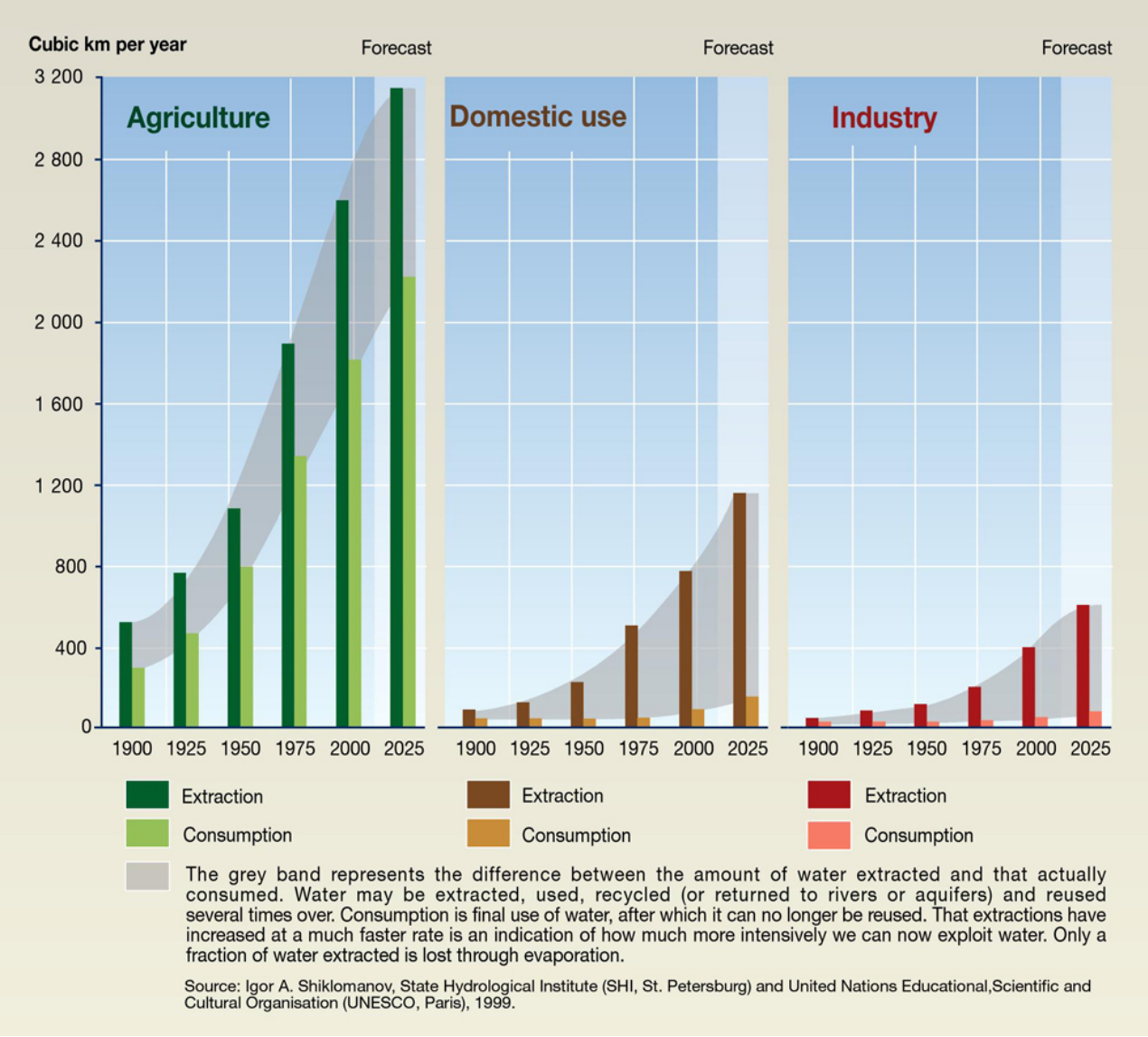




The atmosphere's ability to absorb our waste while remaining 'stable' is an ecosystem service.

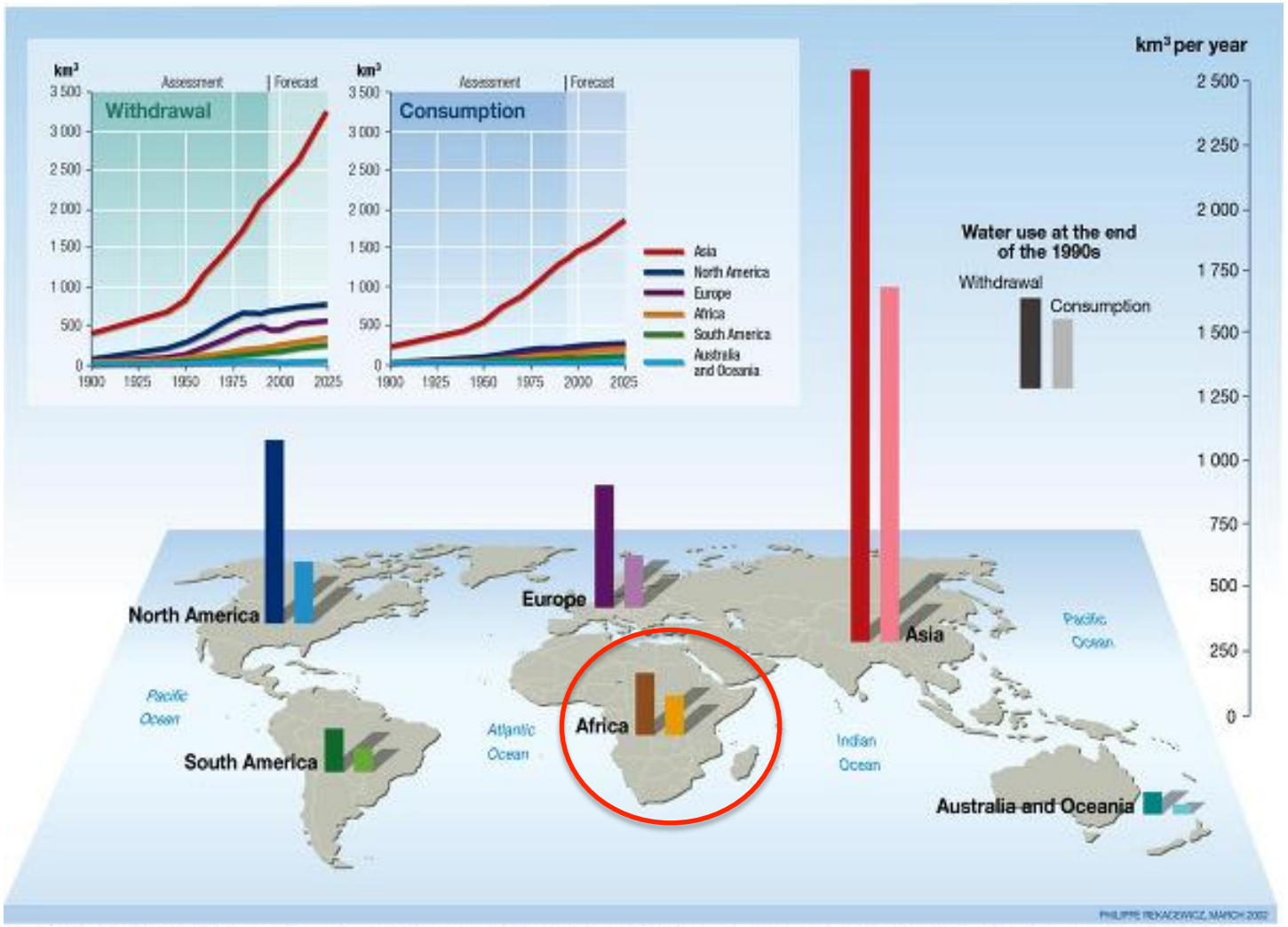
http://www.eia.gov/forecasts/ieo/ U.S. Energy Information Agency International Energy Outlook 2013

Water consumption will increase by ~50% in 2050



Vital water graphics, an overview of the State of the World's Fresh and Marine Waters – 2nd Edition – 2008. UNEP/GRID Arendal

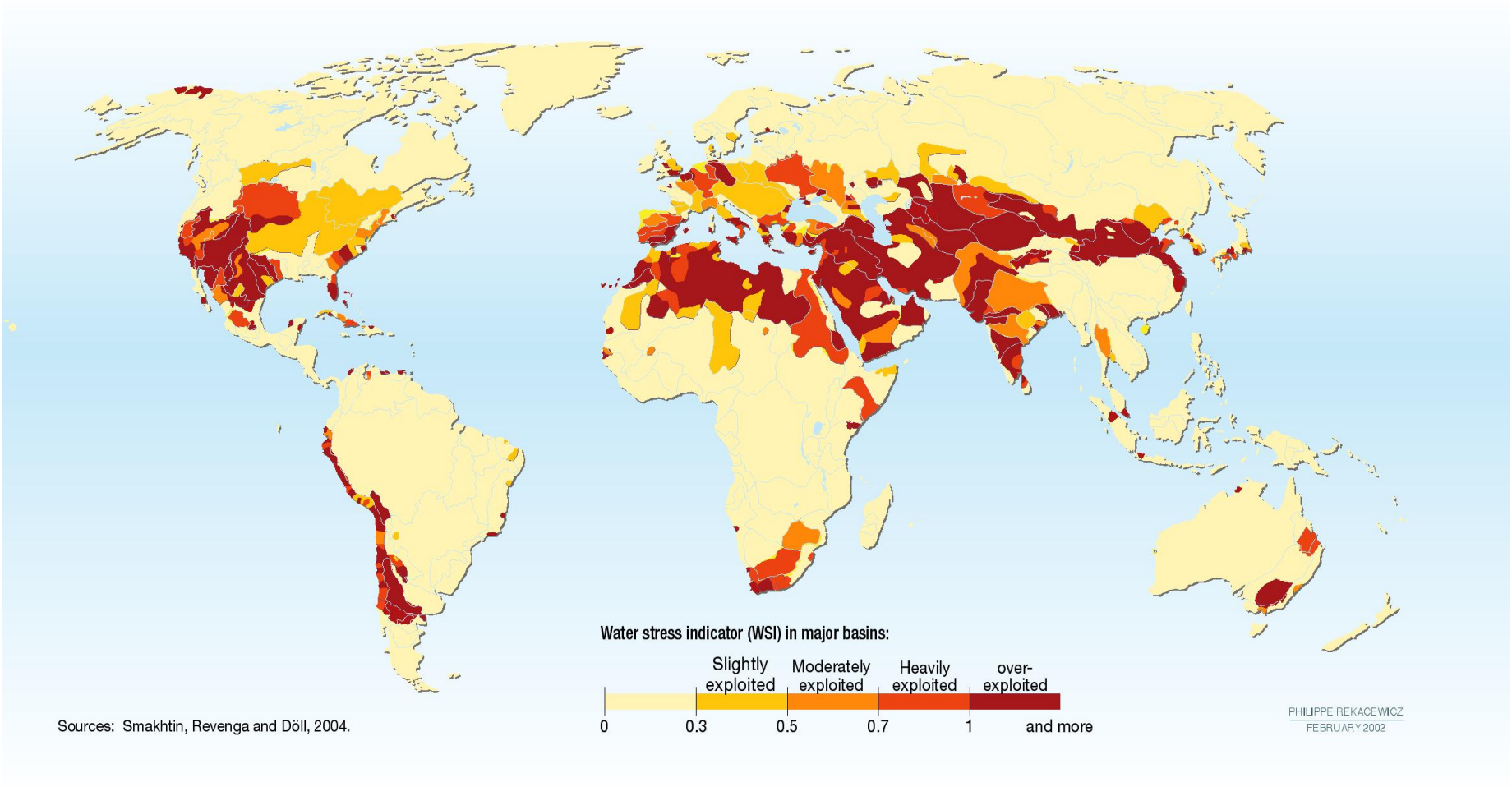
Current global water setting



Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational,Scientific and Cultural Organisation (UNESCO, Paris), 1999; *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI), Washington DC, 2000; Paul Harrison and Fred Pearce, *AAAS Atlas of Population 2001*, American Association for the Advancement of Science, University of California Press, Berkeley.

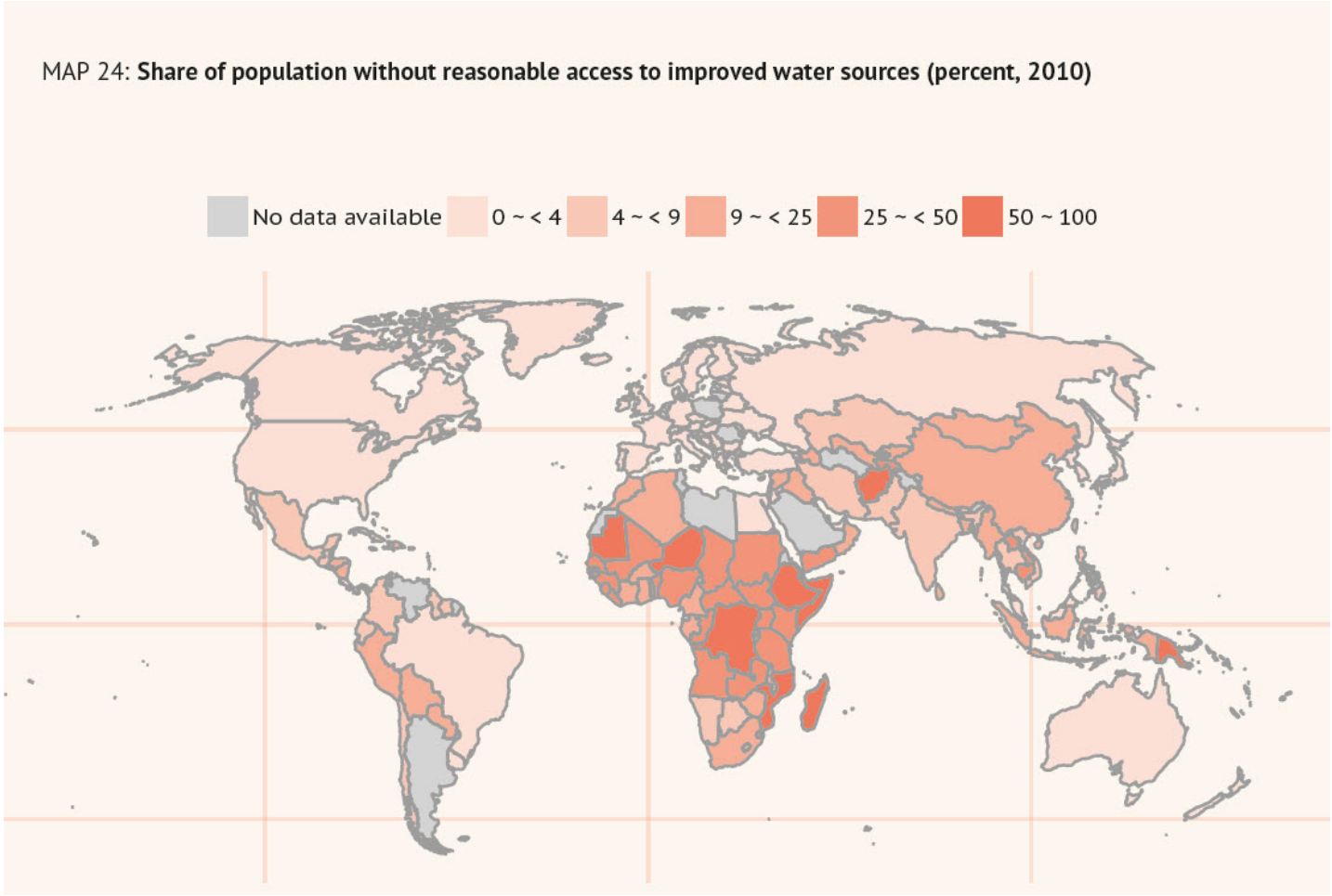
Vital water graphics, an overview of the State of the World's Fresh and Marine Waters – 2nd Edition – 2008. UNEP/GRID Arendal

Current water stress



Vital water graphics, an overview of the State of the World's Fresh and Marine Waters – 2nd Edition – 2008. UNEP/GRID Arendal

Current water scarcity



Share of population without reasonable access to water for sanitation is about the same.

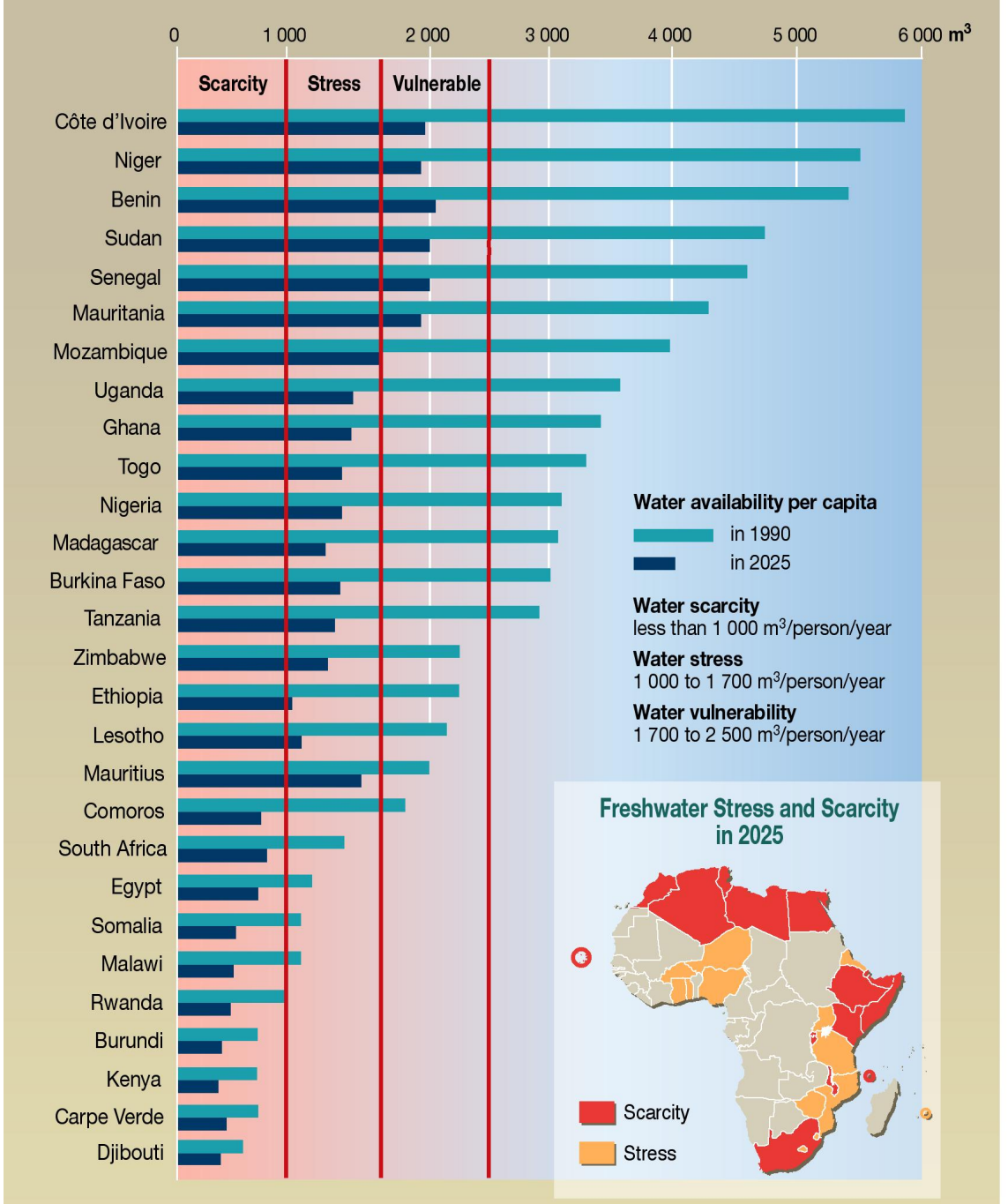
UN Food and Agriculture Organization Statistical Yearbook 2013

Current and future water stress in Africa

Unit is m^3/person/yr

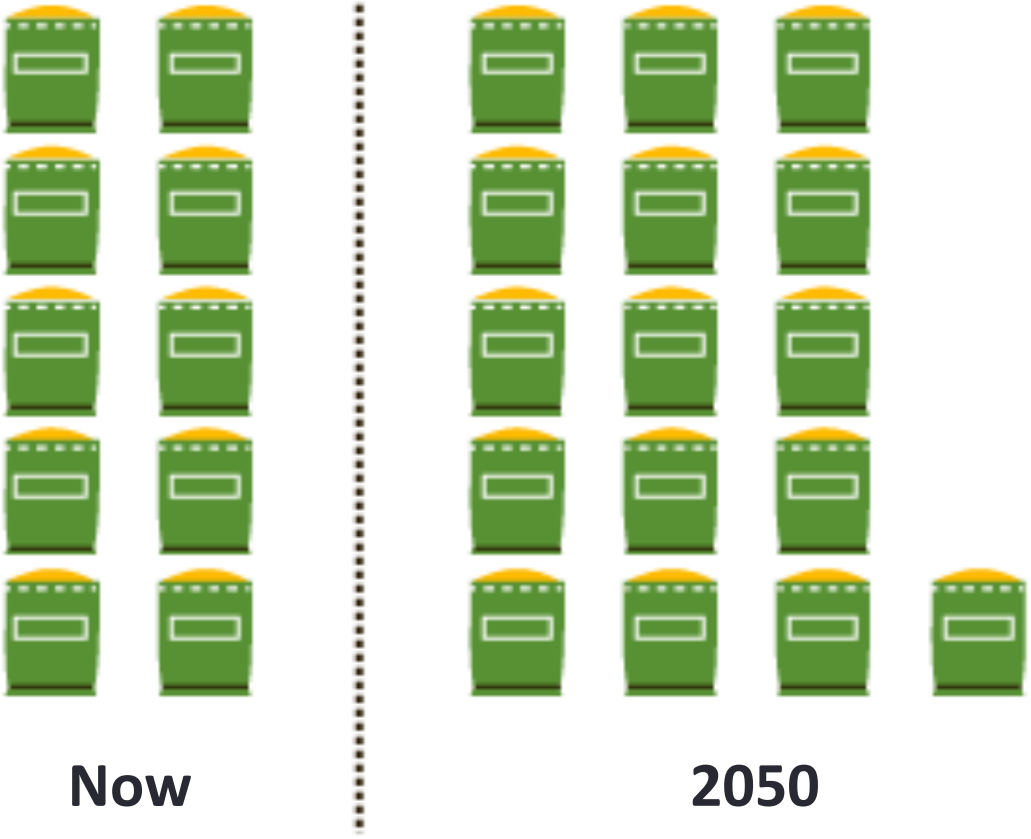
Other Countries

Greenland	10.7M
Canada	94,000
Brazil	48,000
Sierra Leon	36,000
Namibia	10,000
Zambia	10,000
United States	9,000



Food demand will increase by ~50% by 2050

With current global trends in diets and population, **60% MORE FOOD** will be needed in 2050.



Big Facts on Climate Change, Agriculture, and Food Security, Consultative Group on International Agricultural Research (CGIAR) http://ccafs.cgiar.org/bigfacts2014/#

Increasing economy = increasing calories . . .

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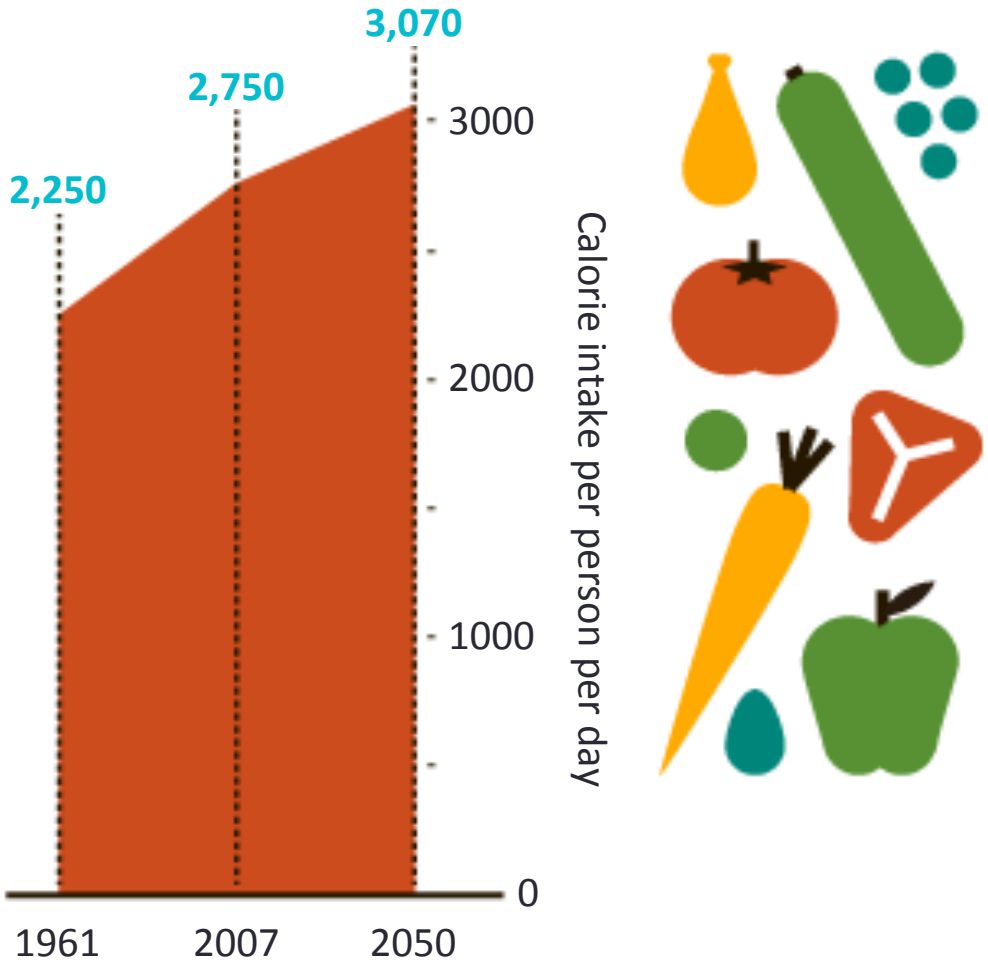
Average calorie consumption is rising.



Big Facts on Climate Change, Agriculture, and Food Security, Consultative Group on International Agricultural Research (CGIAR) http://ccafs.cgiar.org/bigfacts2014/#

And more calories in meat and dairy

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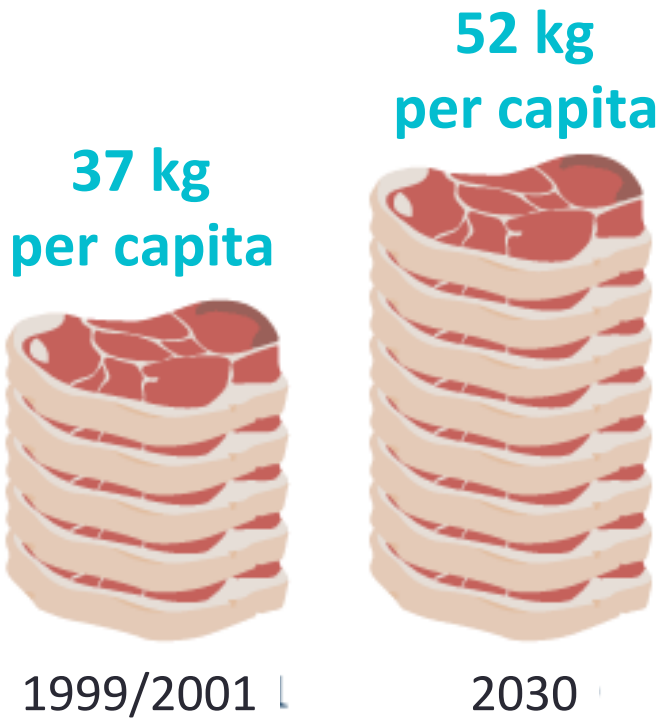
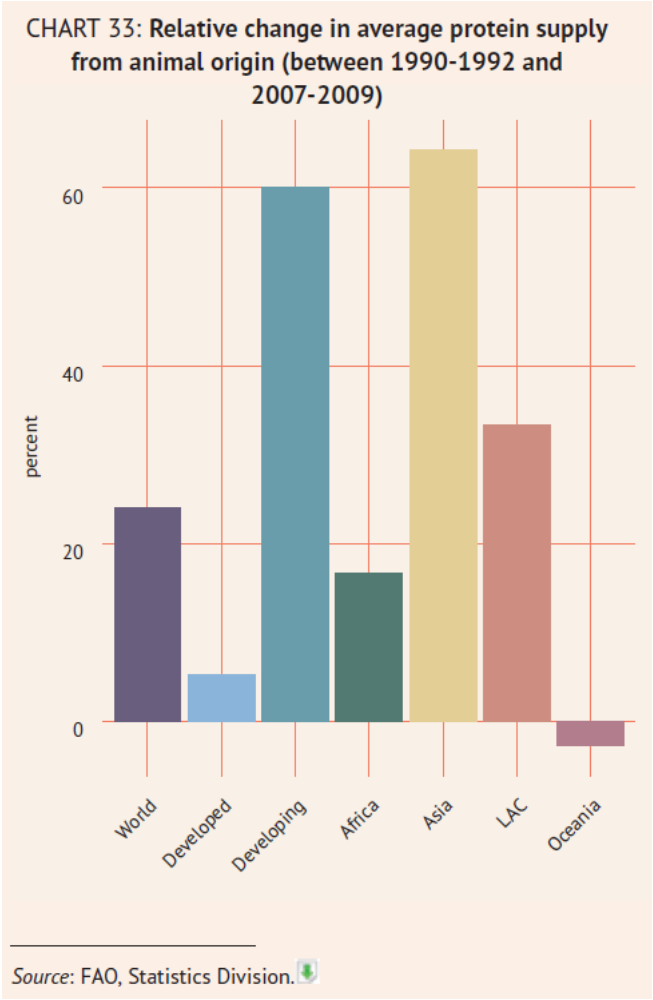
Global Meat Consumption



http://www.unwater.org/water-cooperation-2013/water-cooperation/facts-and-figures/en/



Increasing food demand

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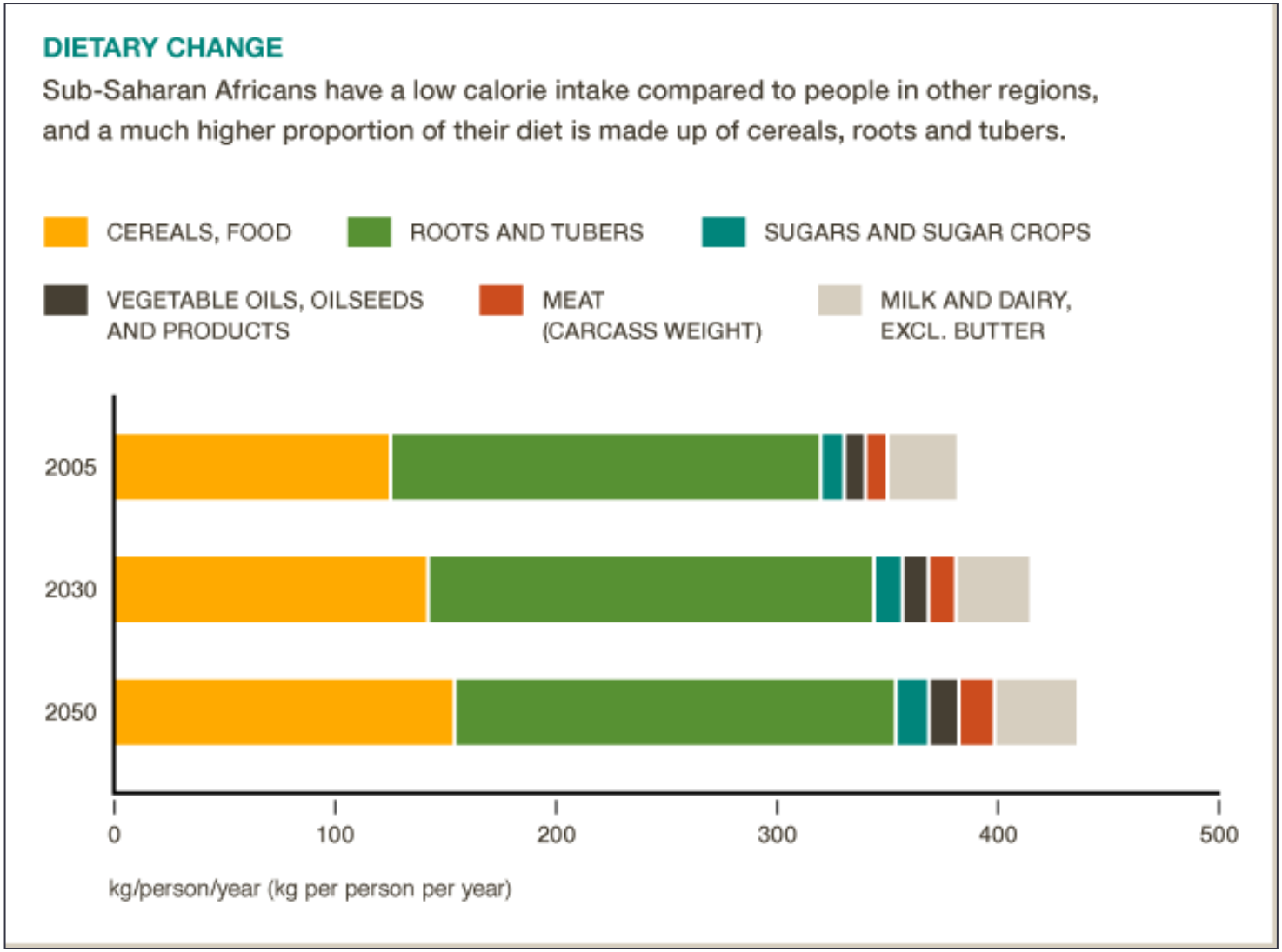

Big Facts on Climate Change, Agriculture, and Food Security, Consultative Group on International Agrictultural Research (CGIAR) http://ccafs.cgiar.org/bigfacts2014/#

Food insecurity is complicated!

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- Food MDGs are being met and hunger reduced in many places around the world
  - But not Africa
- Yields of grains, farmed fish, and meat are increasing
  - But rates of increase for grains are getting smaller
  - Grain stocks are decreasing
  - Ecosystem services are being impaired
  - Natural fisheries are declining
- Distribution is critical
- Many pressures
  - Increasing population and food demand
  - Declining water availability
  - Rising energy costs (fertilizer, diesel fuel, transport, refrigeration)
  - Climate change

Current setting for future food insecurity

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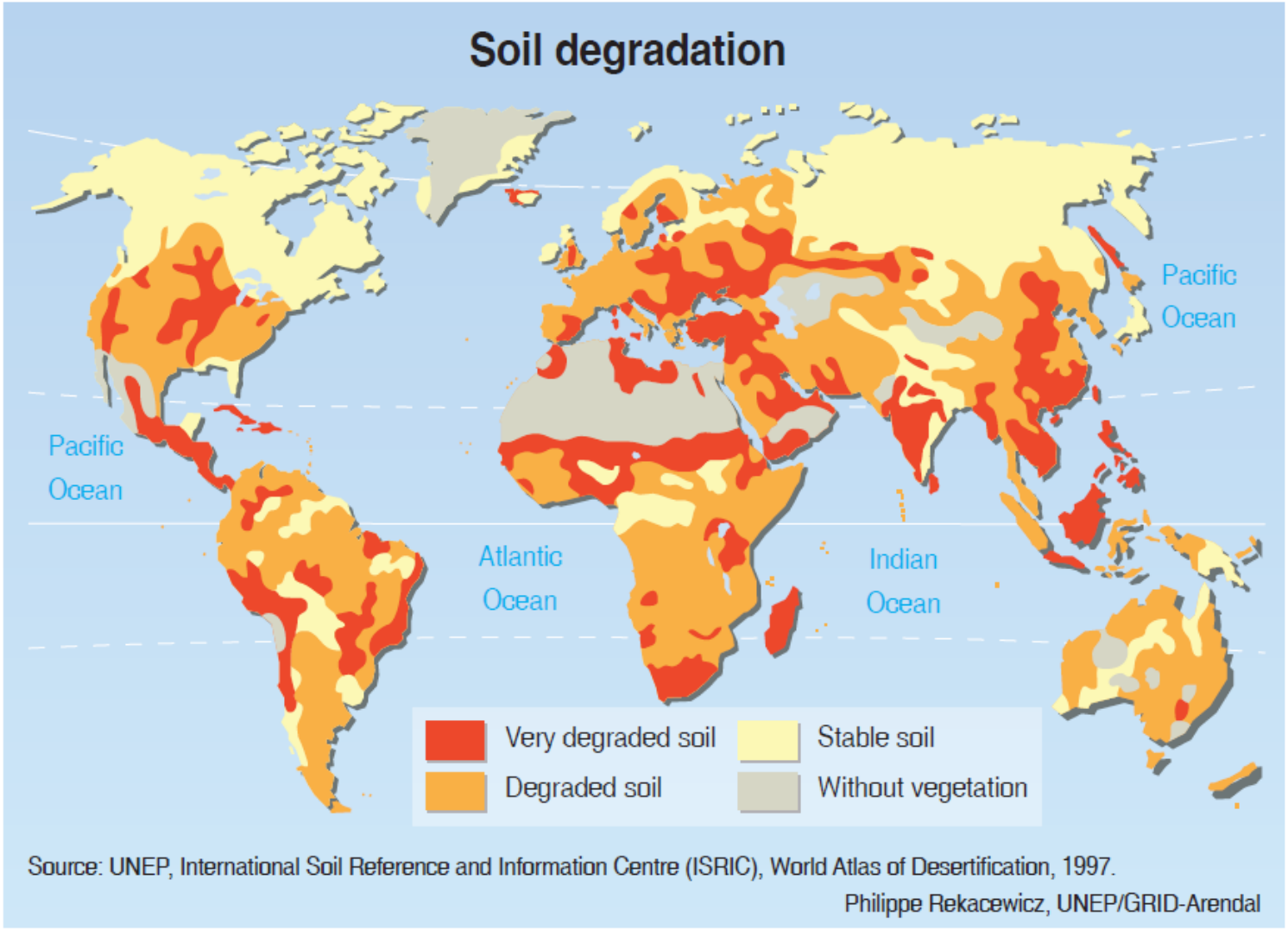
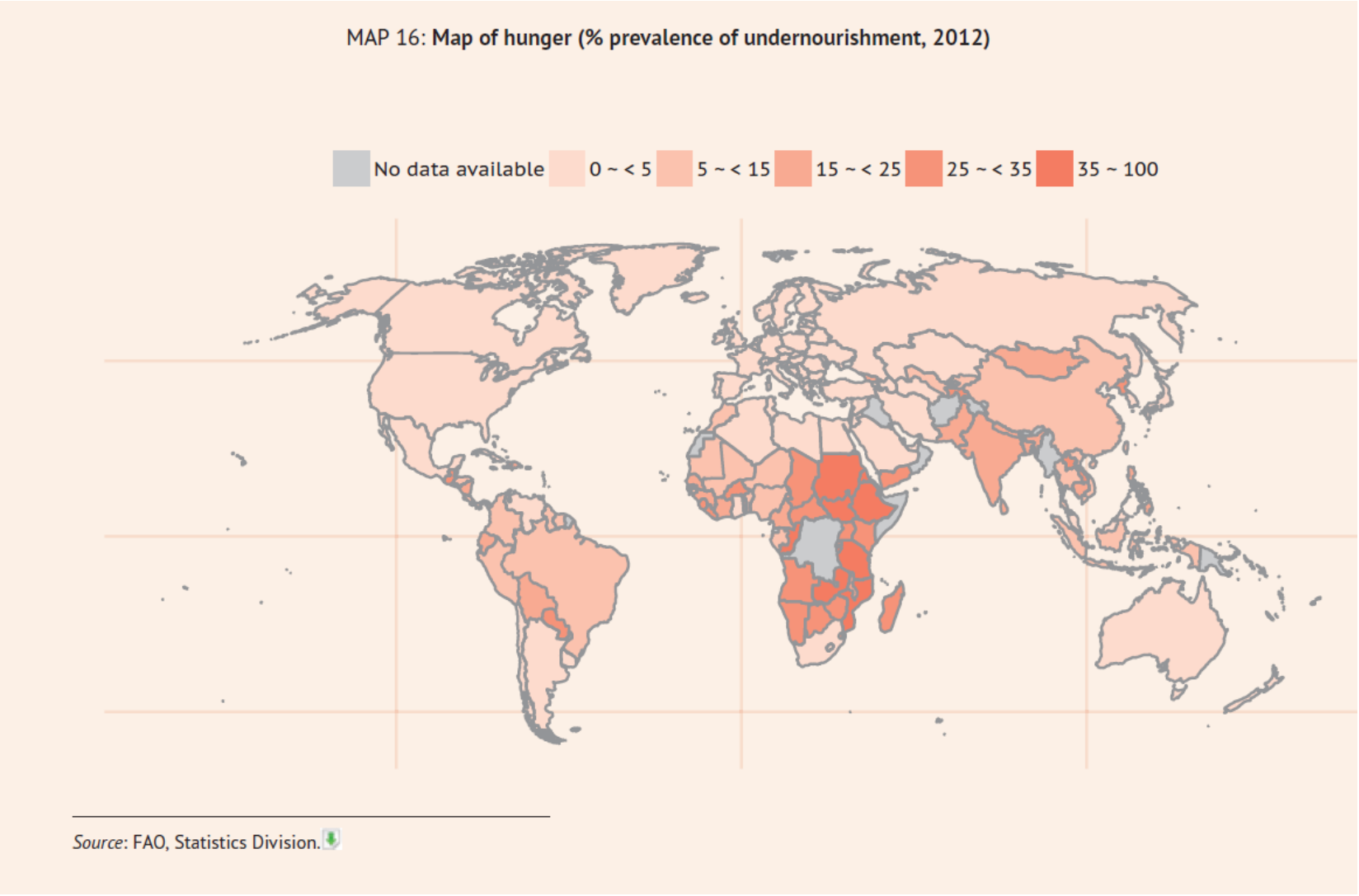


Soil is the product of ecosystem services.

Current setting for future food insecurity

Sandia National Laboratories



UN Food and Agriculture Organization Statistical Yearbook 2013

Potential solutions to water-energy-agriculture-ecosystem problems

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- Reduce population growth rates.
- Separate consumption from quality of life.
- Travel less.
- Eat less meat and dairy.
- Increase efficiencies, waste less.
- Developed world supports 'sustainable' economic development in developing world.
- Invest $83B in ag in developing countries (UN FAO 'How to Feed the World in 2050, http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf

Potential solutions (continued)

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- Create an 'enabling investment environment' for ag, including well functioning input and output markets, improved infrastructure, and better finance and risk management tools. (UN Food and Agriculture Organization Statistical Yearbook 2013)
- Enhance food access by fighting poverty and creating social safety nets. (UN FAO 'How to Feed the World in 2050, http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf
- Subsidize and incentivize sustainability.
- Use new modeling capabilities to evaluate tradeoffs associated with different future strategies for energy-water-ag-ecosystem services management.
- Think big, and think out of the box.

Thanks very much.

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Albuquerque, New Mexico

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505 550 5752

Additional slides

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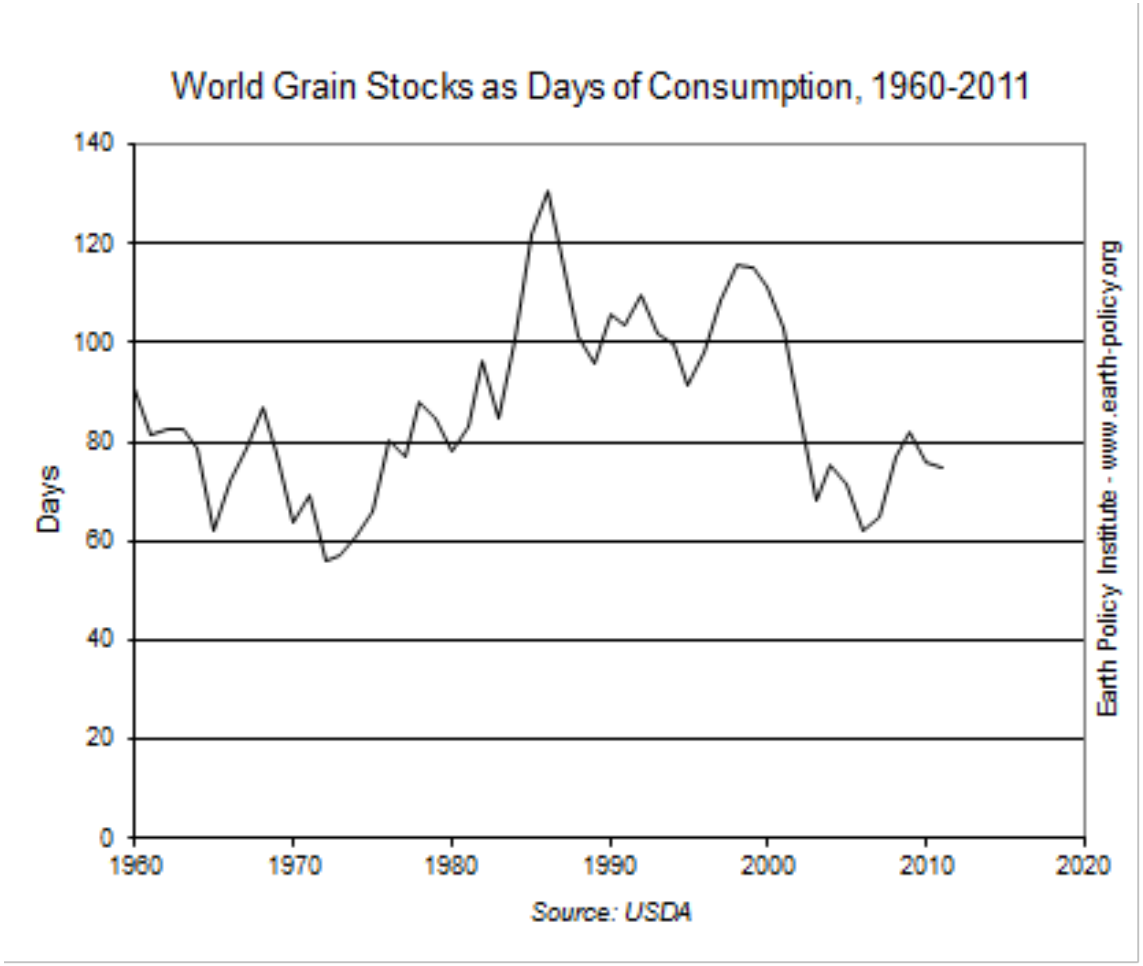
Food insecurity



Composition of fish production

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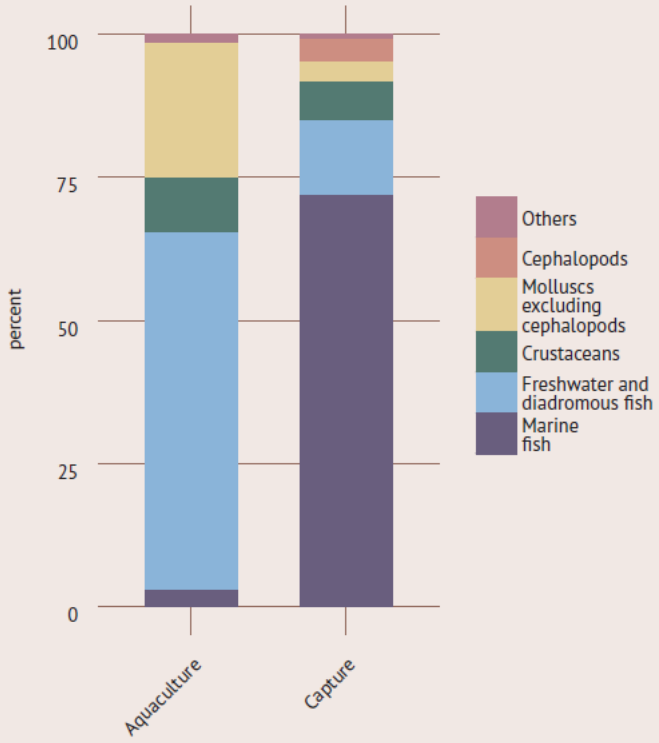
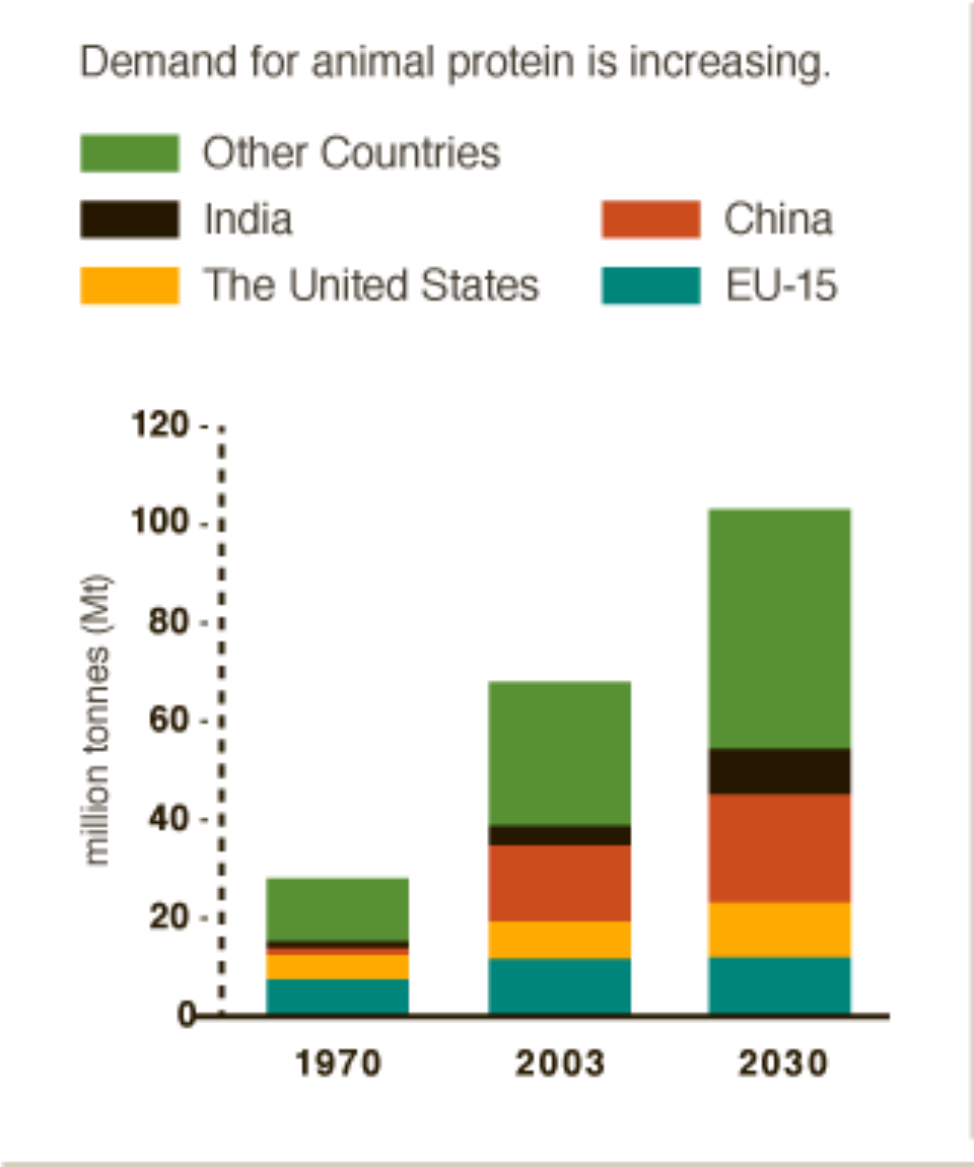
Source: FAO, Fisheries and Aquaculture Department (fishery and aquaculture statistics).

CHART 80: **Composition of fish production (2010)**



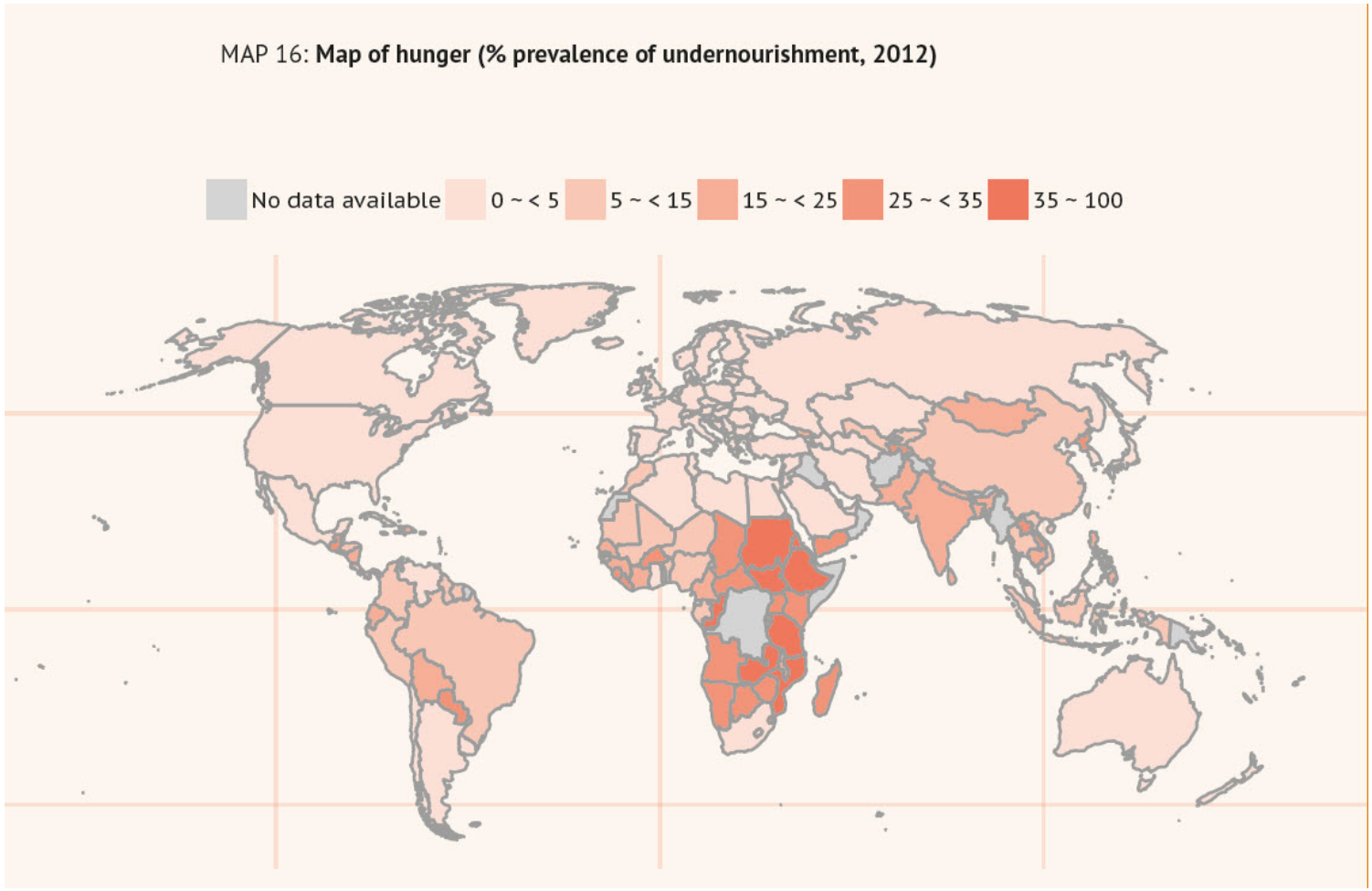
Source: FAO, Fisheries and Aquaculture Department (fishery and aquaculture statistics).

Increasing food demand



Big Facts on Climate Change, Agriculture, and Food Security, Consultative Group on International Agrictultural Research (CGIAR) http://ccafs.cgiar.org/bigfacts2014/#

Prevalence of undernourishment



UN Food and Agriculture Organizataion Statistical Yearbook 2013

Population growth

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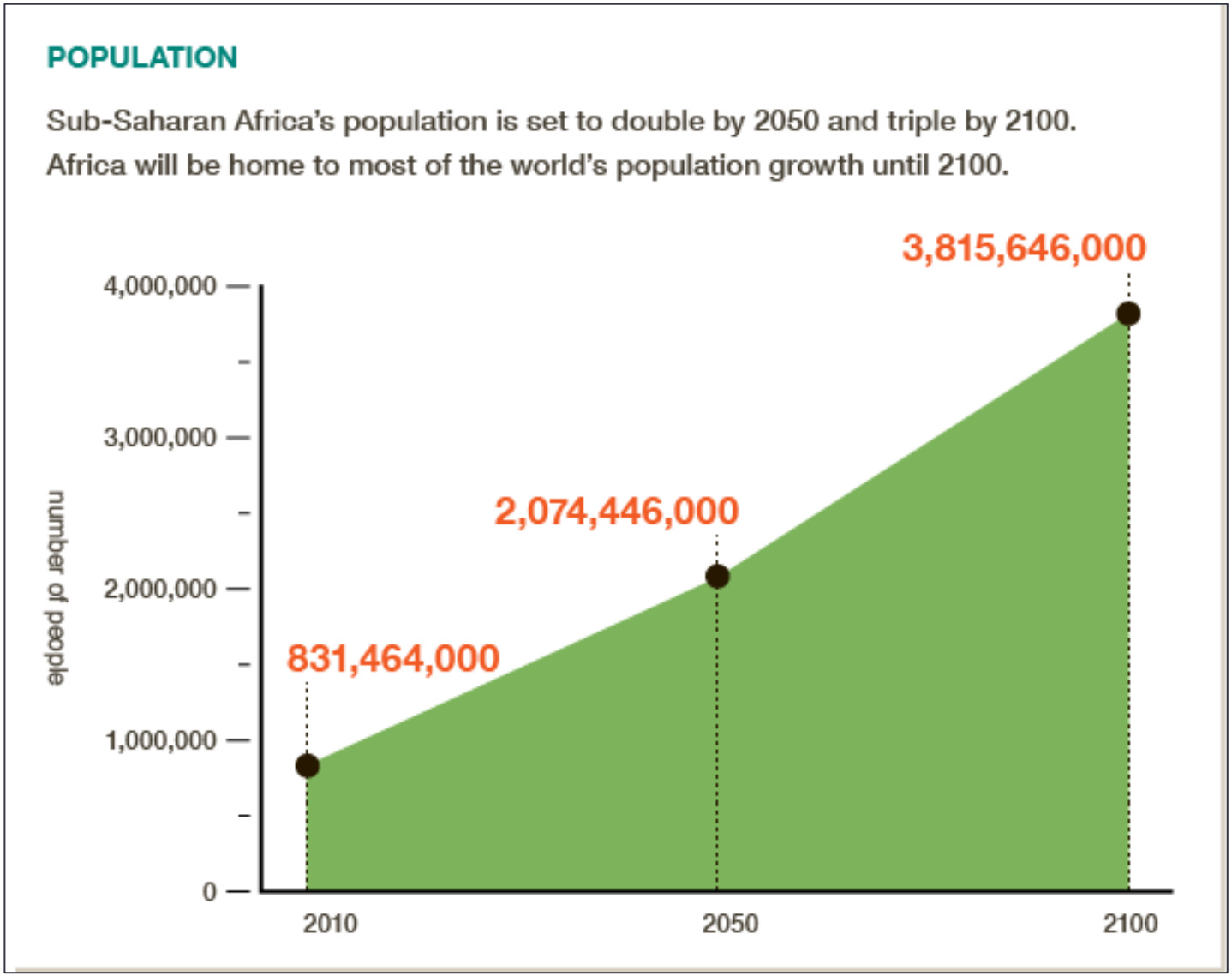

Big Facts on Climate Change, Agriculture, and Food Security, Consultative Group on International Agrictultural Research (CGIAR) http://ccafs.cgiar.org/bigfacts2014/#

Population without water for sanitation

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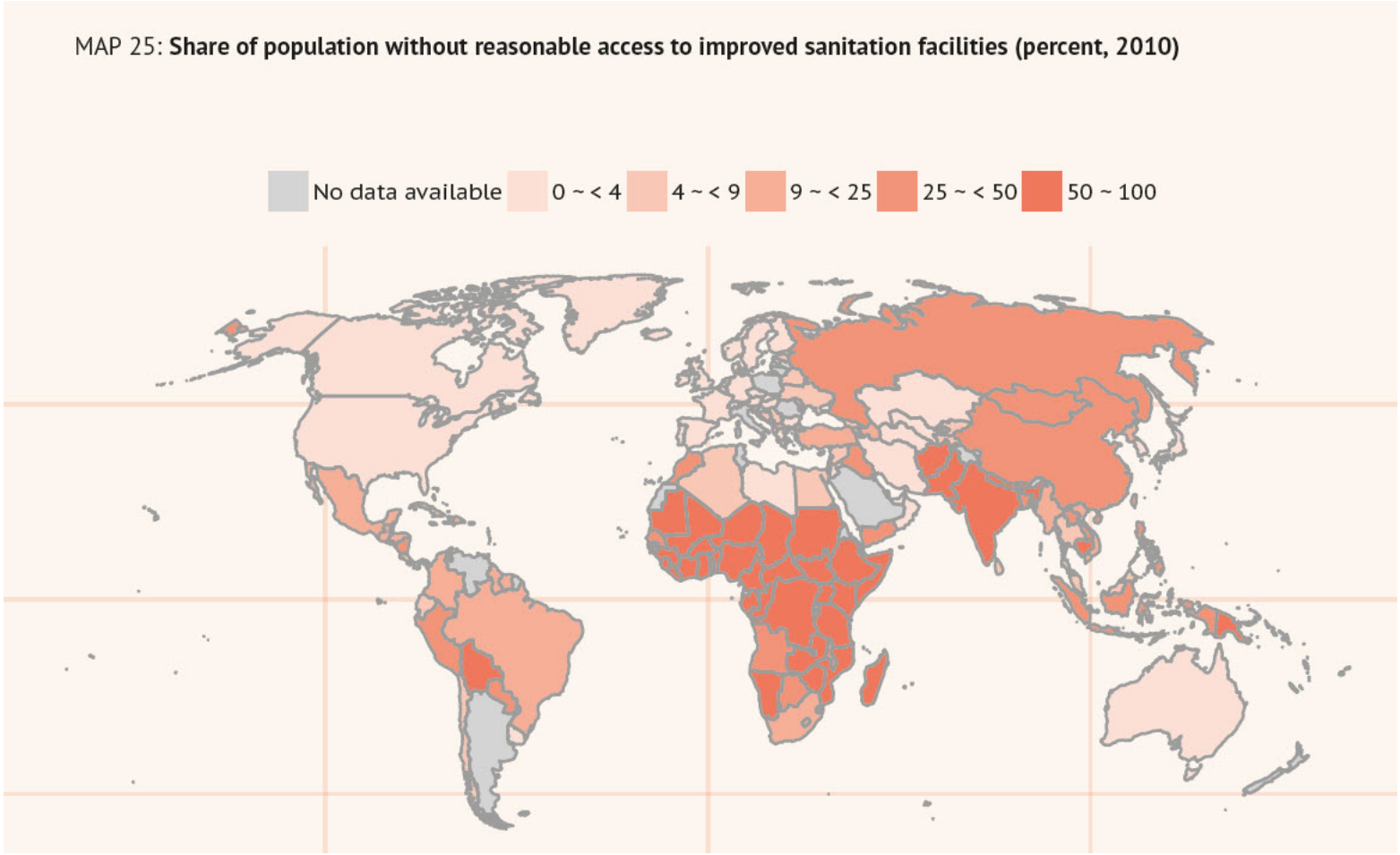
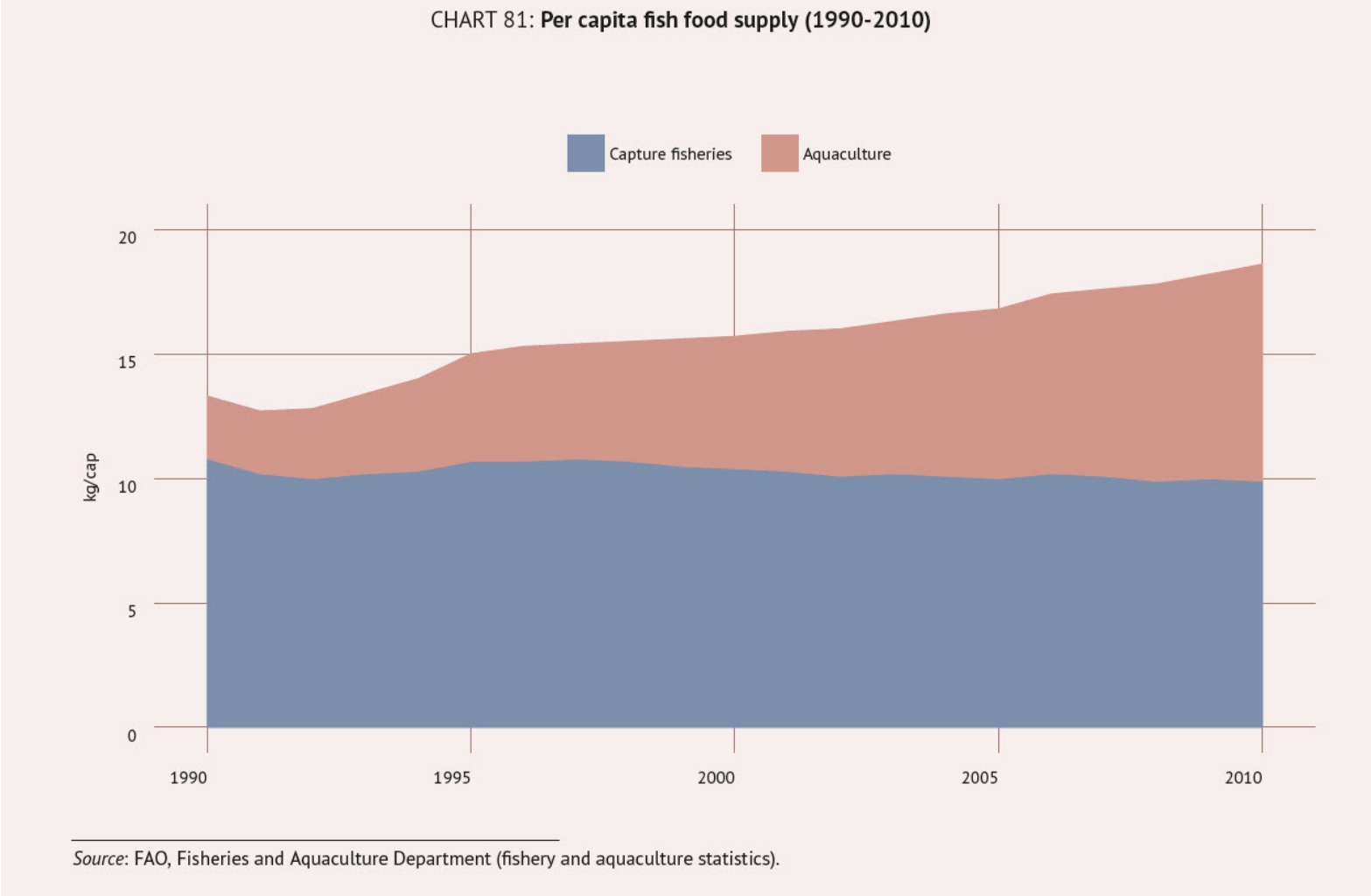


UN Food and Agriculture Organization Statistical Yearbook 2013

Per capita fish supply

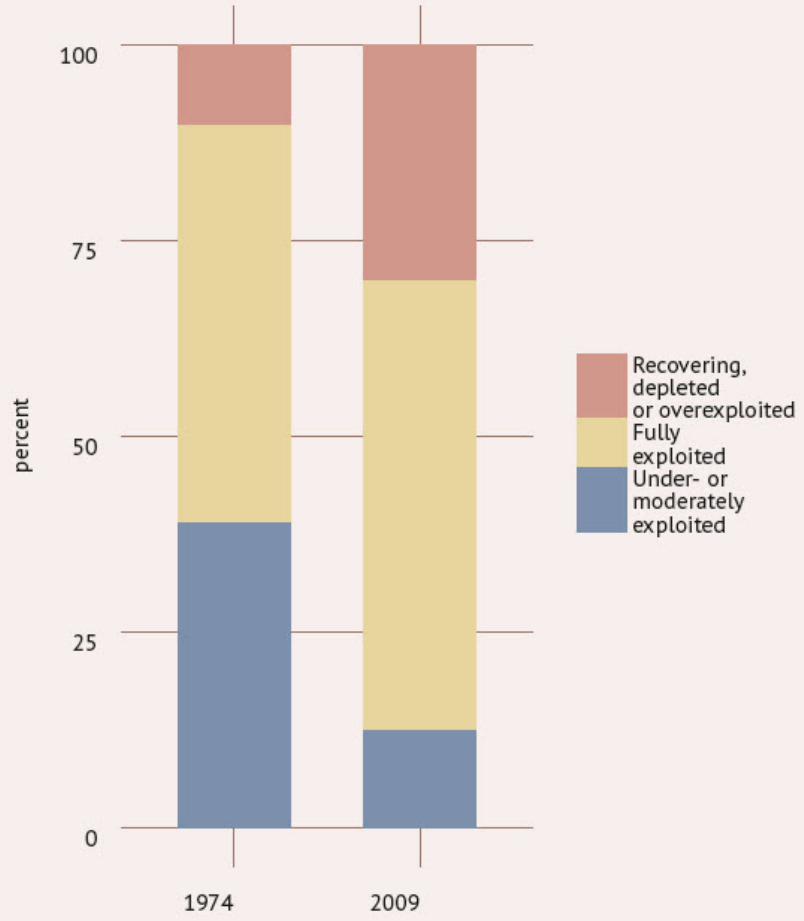


UN Food and Agriculture Organization Statistical Yearbook 2013

Fishery stocks

UN Food and Agriculture Organization
Statistical Yearbook 2013

CHART 79: **State of the world's fishery stocks (1974 and 2009)**



Source: FAO, Fisheries and Aquaculture Department (fishery and aquaculture statistics).

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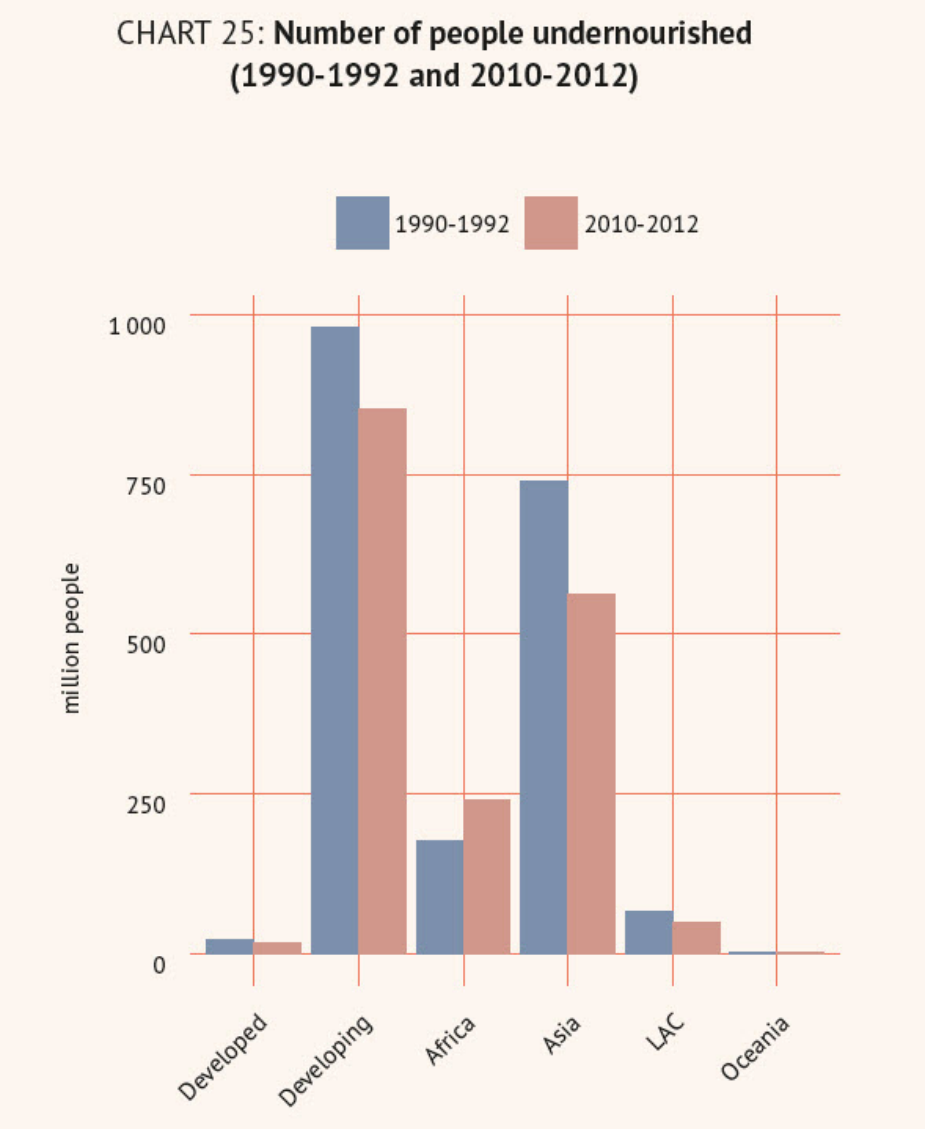
Undernourished people



UN Food and Agriculture Organization
Statistical Yearbook 2013

Declining food availability

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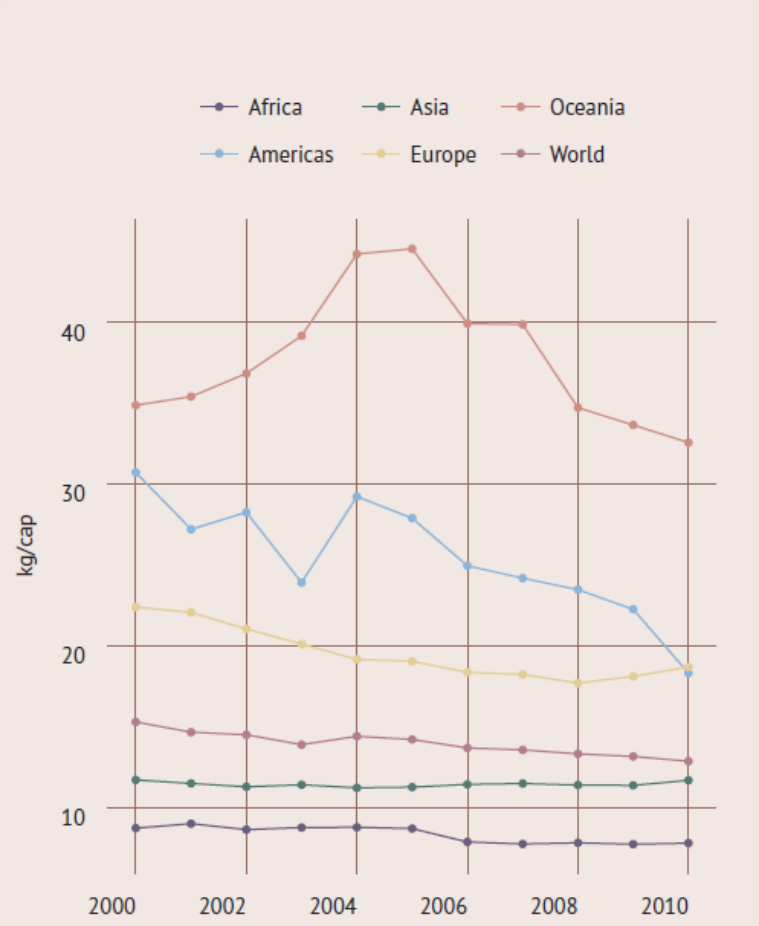
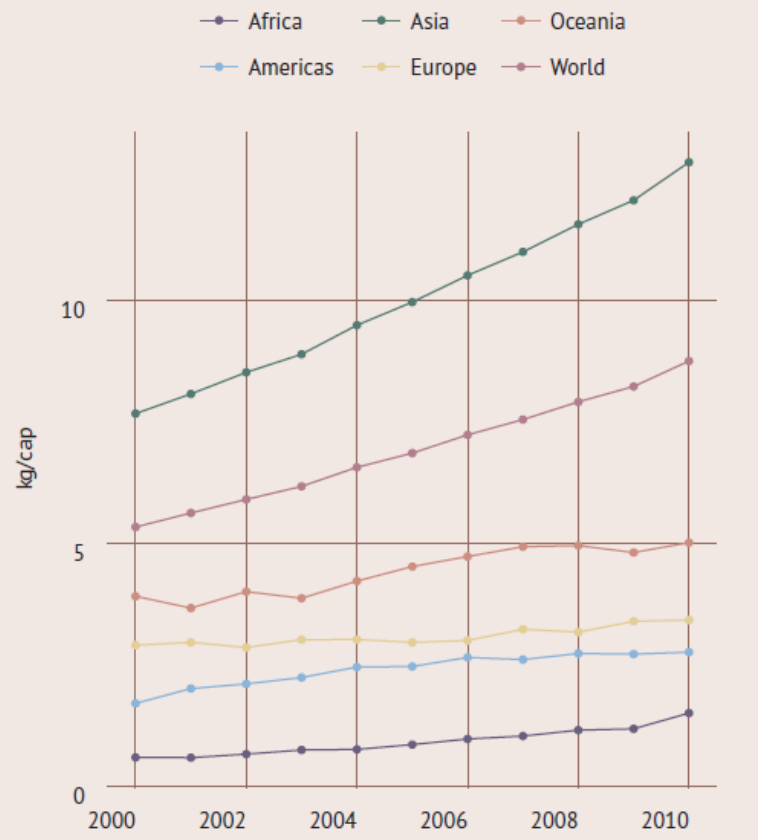
CHART 77: **Per capita capture fish production (2000-2010)**



Source: FAO, Fisheries and Aquaculture Department (fishery and aquaculture statistics).

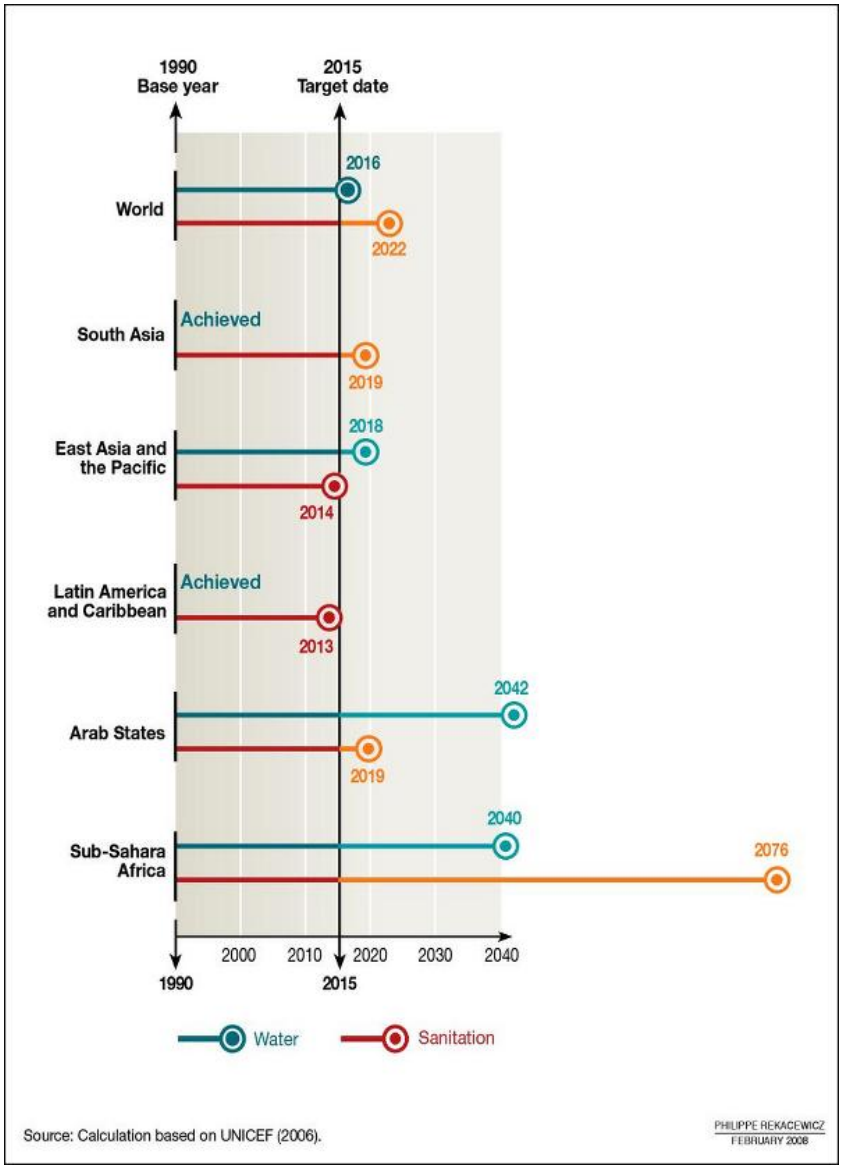
CHART 78: **Per capita aquaculture fish production (2000-2010)**



Source: FAO, Fisheries and Aquaculture Department (fishery and aquaculture statistics).

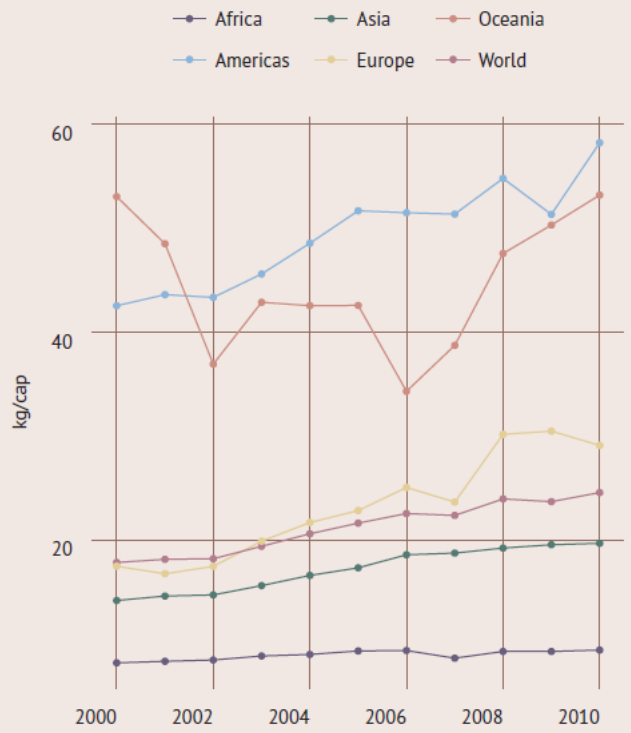
MDGs

Vital water graphics, an overview of the State of the World's Fresh and Marine Waters – 2nd Edition – 2008. UNEP/GRID Arendal



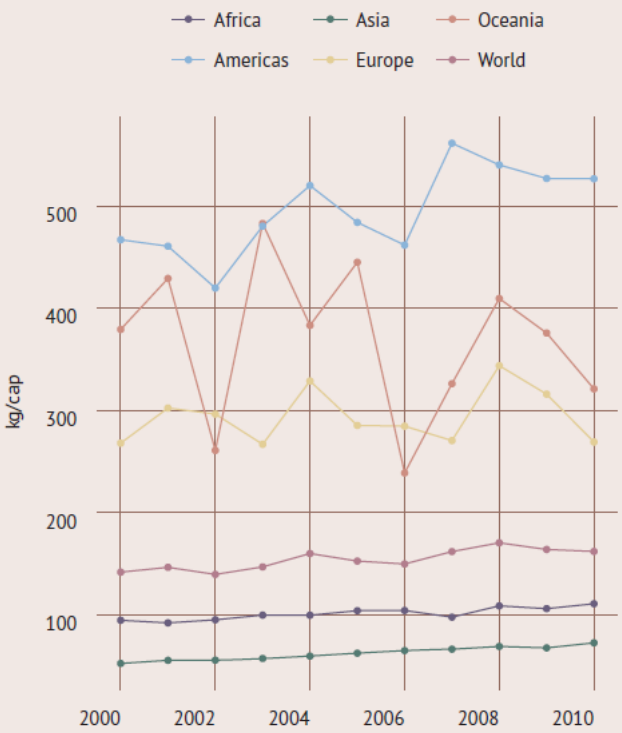
Food availability

CHART 59: **Per capita oil crop production (2000-2010)**



Source: FAO, Statistics Division (FAOSTAT).

CHART 56: **Per capita coarse grain production (2000-2010)**

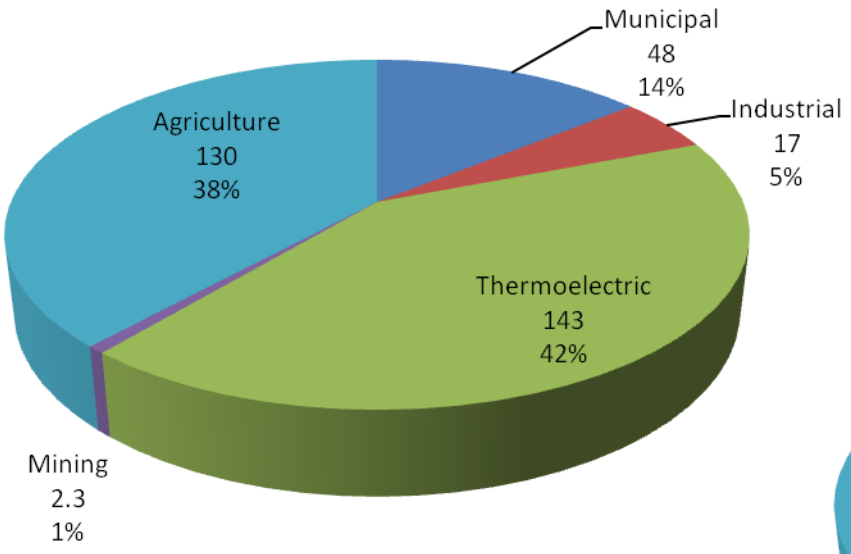


Source: FAO, Statistics Division (FAOSTAT).

Water for thermoelectric power generation

Sandia National Laboratories

Water Withdrawal (BGD)
2005



Water Consumption (BGD)
1995